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MINUTES OF PROCEEDINGS

OF THE

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ROUGH NOTES

ON THE

KABUL-KANDAHAR MARCH

OF AUGUST, 1880,

BY

LT.-COL. G. T. PRETYMAN, R.A.

It has occurred to me that a few rough notes about the march of the force under Sir Frederick Roberts from Kabul to Kandahar in August of last year, may be of interest to my brother officers.

The following lines are not intended to be any complete or detailed version of an operation which has excited much attention, and about which much has already been, and more will be, written.

All that is intended is to give a few jottings of a practical nature, so crude and disconnected I fear, that some apology is needed for putting them forward at all.

It is hardly necessary to observe that the success of a bold project such as that now famous march, demanded much organization and forethought, as well as the best of material in men and transport.

The problem to be solved was to reach Kandahar as quickly as possible, with the possibility of having to encounter opposition on the road, of finding Khelat-i-Ghilzai invested, and with the prospect of a daily difficulty in obtaining sufficient supplies from the country to feed the vast host of fighting men, followers, and animals.

To ensure rapidity of movement, and to allow of forced marches being made, it was evidently necessary that the men should be picked and seasoned, and the transport in first rate order.

For the sake of mobility it was decided to take no wheeled Artillery, nor wheels of any description; so that, had the enemy devastated the country in our front, the advancing column could have turned to the right or left over any passes, into lateral valleys where supplies might be obtained.

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horses were a good deal upset, by observing the variety of food they were able to thrive on in Afghanistan when in hard working condition.

Of course all grain, whether maize, barley, or wheat had to be given them whole.

Order of March.

The order of march varied almost daily, according to the nature of the country, and the road or track to be traversed.

The bulk of the Cavalry were, as a rule, some few miles ahead of the column, one Regiment being detached to cover the rear, and flankers provided to search the surrounding country.

Where it was practicable, and this was often prevented by deep and impassable "*nullahs*" running across the country, the order of march was much as follows:—

The Cavalry disposed more or less as above, viz., in front, on the flanks, and in rear of the whole movement.

The Infantry in line of Brigades with intervals for a partial deployment.

Each Brigade marched as follows:—

1. Advanced Guards, generally containing 1 Battalion and 2 Mountain guns.
2. Two Battalions in column, with the remaining 4 guns. The baggage of, and such trains as might be attached to, the Brigade.
3. The remaining Battalion, bringing up the rear of its Brigade.

Often, however, the front of each Brigade had to be narrowed, or indeed the features of the ground would oblige the whole force to defile along one track. In this latter case, the irksome duties of the Rear Guard were much increased, and the long line of march, sometimes as much as 6 miles, demanded a larger force of Cavalry on the flanks.

The Rear Guard was often under arms for 14 or 16 hours.

Time of Marching.

Advantage was taken of moonlight, during part of the march, to start very early, even at 2 or 3 a.m., in order to save the men and animals as much as possible from the fierce heat of an August sun in Afghanistan.

As is well known, no opposition was met with on the road down, though stragglers were always cut off, and predatory bodies of Afghans hung on the flanks and rear of the column.

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Sufficient supplies were found, though often with considerable difficulty, and the labours of Political and Commissariat Officers, and of the Cavalry, would generally begin when the camping ground was reached.

Sites of Camps.

The site for the camp was always chosen with reference to the length of the march, the supply of water at hand, and the amount of crops of maize to be found for the animals. There were generally villages in the vicinity of cultivation.

The first halt was made at Khelat-i-Ghilzai, which was found not to be invested. The garrison had collected some supplies for the Kabul force, and joined that force in its onward march to Kandahar.

It was soon evident that Ayub Khan meant to stand, although he had withdrawn his investment of Kandahar itself. Shorter marches were now made so as to bring the troops in comparatively fresh.

Heliograph.

The heliograph, as constantly happened during the Afghan war, was here employed with great success. Communication over a distance of more than 20 miles being established with the Kandahar garrison, by which news was obtained of their exact condition, and details of their stores, and supplies of all sorts still remaining.

The reconnaissance of the 31st August, and the battle of the following day are well known.

Artillery.

The brunt of the fighting in Afghanistan, both from the nature of the country and the particular style of warfare of the people, was of necessity borne by the Infantry.

Artillery had not as a rule so much scope for its action, although there were, of course, several occasions on which individual Batteries did good and gallant service. It would seem that the best effects of Artillery fire could not be developed from isolated Batteries, a concentrated fire from a large number of guns appearing to be necessary to produce any great results.

During the attack of the 1st September on Ayub's position, there was an occasion when the combined fire of two Batteries (one, a 9-pr. Field Battery, the other a 7-pr. screw gun Mountain Battery) did excellent service. I refer to the taking of a strongly posted village filled with Afghans, which, in the early part of the day was stormed by the 92nd Highlanders and the 2nd Ghoorkhas. The shell fire of these Batteries during the advance of the Infantry, greatly aided the latter, and kept down the musketry fire of the enemy, who crowded on to every house-top of the village to defend it. The fire of these guns palpably saved the Infantry from considerable loss.

But Field Artillery has no effect against the actual walls of an Afghan

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village. These, though built of mud, become in time almost as hard and solid as concrete, besides being of considerable thickness, so that light shell striking them do no damage.

From the experience of this campaign, it would appear that in a difficult and hilly country, Mountain Artillery alone is required for operations in the field.

This may be of two kinds, an ordinary 7-pr. for ranges up to about 1,000 or 1,200 yards; and a jointed gun, perhaps a 9-pr. (if possible) for longer ranges.

When quick movements are necessary in a mountainous district, it is obvious that mule guns and pack transport alone are practicable.

There may be occasions when heavy Artillery, such as 40-prs. or even 64-prs. would be requisite: or better still, a good rifled howitzer throwing a large capacity shell.

I allude, of course, to anything like a bombardment or siege of some strong place.

For ordinary operations in such countries, however, it would seem that the disadvantages of wheels and extra horses, do not compensate for the advantages of the shell power of Horse or Field Batteries.

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SIEGE OF POTCHEFSTROOM.

BY

LIEUT. H. M. L. RUNDLE, R.A.

On Saturday, 13th November, 1880, it was rumoured in the camp at Pretoria that a riot had taken place at Potchefstroom, the old capital of the Transvaal. Three hundred Boers had ridden into the town and forcibly taken away a wagon, which was being sold by order of the Landrost for arrears of taxes. It was known by 5 p.m. that at the request of the government a small force was under orders to march on the following day at 1 o'clock for Potchefstroom.

The troops at this time stationed at Pretoria were—

Head Quarters and five guns N/5 R.A.			
"	2nd Comp. R.E.	strength about	45
"	2/21st Royal Scots Fusiliers	" "	350
One Troop of Mounted Infantry		" "	35
A few men of the Army Service and Army Hospital Corps.			

Out of this force the following were formed into a "Field Force" under the command of Major C. Thornhill, R.A., and marched for Potchefstroom in less than 24 hours from the time the orders were received, viz. :—

Two guns, N/5, R.A.
25 Mounted Infantry.
1 Company Royal Scots Fusiliers—strength, 75.

This force marched into Potchefstroom at 2 p.m. on the 18th inst., having thus done the 104 miles in 96 hours. The camp was formed on rising ground, with a laager for the horses and mules in the centre, about half a mile to the west of the town, and overlooking it.

On the 20th inst. the force was further strengthened by the arrival

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of another Company of the Royal Scots Fusiliers from Rustensburg, under the command of Lieut. R. A. Browne, R.S.F.: strength 49 N.-C.-O.'s and men.

It was not till several days after the arrival of the troops that orders were received to build a fort, which was accordingly commenced; but owing to a paucity of entrenching tools, it was no more, when the siege commenced, than a shelter trench 4 ft. 6 ins. in height and 25 ft. square, in which were placed the Commissariat Stores and Hospital.

Early in the month of December it became apparent that the aspect of affairs was much more serious than had been at first imagined. The Colonial Secretary came down, but failed to arrange matters with the malcontent Boers, who had collected in large numbers at Loverskania. The Colonial Secretary was succeeded by Major Clarke, R.A., C.M.G., as Special Commissioner.

Efforts were made about this time by a few of the leading inhabitants to raise volunteers to assist the troops in the defence of the town in event of its being attacked. These efforts failed owing to the sympathy of the townspeople with the Boers. A few special constables however were enrolled under Commandant Raafe, C.M.G., some 20 in number. About the 12th of December it was known that the Boers had announced their intention of re-taking their old capital and hoisting their flag on the 16th December; this day being auspicious to them as the anniversary of their victory over the Zulu King Dingaan, and commonly known amongst them as "Dingaan's Day."

On the 12th inst. Lt.-Col. Winsloe 2/21st R.S.F. arrived to take command, and relieve Major Thornhill, who being in command of the Royal Artillery in S. Africa was ordered to rejoin Head Quarters at Pretoria.

Such was the state of affairs on Wednesday, 15th December, when Major Thornhill, in accordance with his orders, left about 12 o'clock to take his seat in the post cart to rejoin Head Quarters at Pretoria. He had only reached the Landrost's office when he was sent back at full gallop by Major Clarke, to give the camp warning that the Boers were at the moment entering the town, armed, and in force. In a very short time the horses were in the ditch, the guns in action, the parapets manned, tents struck, and everything in readiness to withstand an attack.

Captain Falls with 24 men were at once marched to the government offices, which were also garrisoned by Commandant Raafe and his special constables. Major Clarke also took up his position there. Lieut. Dalrymple Hay and 22 men occupied the gaol. Deputy-Assist.-Com.-Gen. Dunne, Commissariat Staff, was also with this party. The Boers to the number of nearly 800 off-saddled on the outskirts to the north of the town, sending parties into it to occupy the principal streets. In the afternoon several of the inhabitants, the Portuguese Consul General, Chevalier Forsmann and his family, Dr. Sketchley, District Surgeon and his wife, sought refuge in the camp.

During the day the Boers had contented themselves with patrolling the streets and congregating to the number of two or three hundred in the centre of the town. They had also taken possession of the printing offices.

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Towards evening, however, they went further, and stopped several of the inhabitants, preventing them from going down certain streets. The Special Commissioner was stopped while riding from the fort to the Landrost's office, and later on the Manager of the Standard Bank was taken prisoner while walking to the fort, and kept so until morning. Matters thus began to look serious; still the military were not allowed to act, and it was supposed by those in authority that after issuing a proclamation the Boers would quietly leave on the following morning.

The position on the morning of the outbreak of hostilities was briefly this: the enemy held the town, with its lines of walls, gardens, &c., while the troops occupied the fort (which was, as previously stated, nothing more than a shelter trench), the gaol and Landrost's office. The two guns were in shallow gun-pits about 2 feet deep at the N.E. corner of the fort, facing the cemetery. Between the fort and the gaol a distance of 360 yards was open "*veldt*," sloping from the former to the latter, crossed by a water furrow about 40 yards from the gaol. Between the gaol and Landrost's office, a distance of about 400 yards, the space was intersected by garden walls and hedge rows. The gaol itself was a square building with walls 20 feet high, standing in comparatively open ground. The Landrost's office on the contrary was surrounded by walls and houses with thatched roofs, one house almost touching it; and afforded no range for fire except across the square to its front. In matter of position, therefore, the enemy had every advantage.

The town itself, about 1½ miles in length and ½ mile broad, was peculiarly adapted for defence, being intersected by garden walls and hedge rows, the gardens being well wooded. The houses were for the most part scattered and detached, except in the market square and principal streets. Thus the enemy were able to take up any position they pleased without being seen from the fort, and could open fire within 600 yards without leaving cover. The Boers held possession of the town, with the aforementioned exceptions, before hostilities commenced. The troops as yet had had no orders given them to act, and no one could say what the next move in the game would be. Matters, however, gradually developed themselves.

About 9 a.m. a patrol of the enemy left the cover at the north of the town, and slowly walked their horses past between the fort and the gaol, turning off into the town as soon as they had passed the latter building. Colonel Winsloe, on this, sent some of the Mounted Infantry to warn them that he could not allow mounted patrols so near his camp. The patrol, by the time the Mounted Infantry reached them, had re-entered the town, and on the Mounted Infantry attempting to follow them, the Boer picquet stationed at the corner of the street opened fire. The Mounted Infantry in return fired upon the picquet and the mounted patrol, wounding one man. They were then recalled. Shortly after this the Boers entered the market-square in force, and were fired upon by Captain Falls from the Landrost's office. The attack now became general; the enemy opening fire from their line of walls, and throwing out a right and left attack—the latter of which was never developed. The head of the right attack reached the cemetery wall which the Boers

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occupied only for a short time, being driven back by the fire of the two guns. The Artillery fire also broke the advance of the main body, which fled to the north end of the town. The Landrost's office and gaol were at the same time hotly engaged, the enemy occupying the neighbouring houses and gardens. The Landrost's office was supported by Artillery fire from the fort. The fire slackened, and ceased about 11 o'clock. The strength of the enemy was finally 800, the original number being 500. The Mounted Infantry on going out to bring in some horses were fired on from the right of the enemy's line, and obliged to retire, one horse being killed. On the Artillery going to water in the afternoon under cover of fire from the gaol, a heavy fire was opened on them from the left of the enemy's position, which wounded one man, killed one horse, and wounded four others.

At the Landrost's office affairs for the first time began to look critical. Major Clarke reported the square strongly held, the Boers occupying the gardens in rear of it. He further reported that Captain Falls had been killed early in the day, and that several men were wounded. It was now apparent that although the Boers had been repulsed, they were still in force round the position. Colonel Winsloe suggested to Major Clarke, on whom the command at the Landrost's office had devolved, the advisability of retiring on the gaol, a distance of 400 yards. Major Clarke replied that he did not think it advisable, on account of the moral effect.

As the enemy commanded the watering-place, the supply of water became a matter of serious consideration. Sufficient water for the troops was obtained in the water carts, about 1200 yds. from camp up the stream. In the evening the horses and mules were watered at the same place, but two trips had to be made to fill the reserve barrels. By this means water was obtained sufficient to last the troops for three days. A well had been commenced at the same time as the fort, but as yet yielded no supply of water, although 20 ft. deep. It had struck on rock and little progress could be made with it.

On the 17th, and up till 10 a.m. on the 18th, there was little or no firing; a few shots were heard from the Landrost's office, and it was accordingly supported by Artillery fire from the fort. Communications, which had been established by signallers, became interrupted, and we could get no news of what was going on. About 10 a.m., to the surprise of everyone, the Union Jack was seen to be hauled down and a white flag hoisted in its place.

Many were the suggestions as to the cause—few guessed the real one, viz., that Major Clarke had been obliged to surrender. Shortly afterwards a flag of truce came up to the fort carried by Erasmus, one of the leading Boers, who brought a letter which stated that Major Clarke, finding the position he held untenable, surrendered the whole of his garrison unconditionally to General Cronjie, commanding the Boer forces. This surrender was accepted, and the lives of the garrison guaranteed and good treatment promised them. The Landrost's office had been completely surrounded before it surrendered. The Boers had got up to within 12 feet of the loop holes, and succeeded in setting fire to the thatched roof; and our men were unable to fire towards the end.

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Colonel Winsloe acknowledged the receipt of this document, stating in reply that it in no way affected the other positions held by H.M. troops under his command. By this surrender the force was diminished by 24 men. A truce was proclaimed until 4 p.m., to enable the conditions of the surrender to be carried out. This truce was not strictly observed by the enemy, who wounded severely a man at the gaol while both their and our flags of truce were flying.

Up to this time the guns had practically been fought in the open; advantage was, however, taken of the truce to traverse them and deepen the gun pits. The fort was strengthened as far as time would permit. The enemy also considerably strengthened their positions. At 4 p.m. precisely the Boers opened a heavy fire on the gaol and fort, rendering the working of the guns a matter of some difficulty. The gaol, particularly, was hotly engaged; the enemy massing in the houses behind it, and firing with such accuracy that the parapets on some occasions could hardly be manned, although loop-holed. The enemy's fire was returned, first by Artillery fire from the fort, and then by Infantry. The line occupied by the enemy was so extended that it was only feasible to silence it in detail; and after one or two effective shells at any particular spot it generally followed that the fire from that point slackened.

During the afternoon it was decided that, as the Landrost's office no longer formed part of our position, the necessity of holding the gaol no longer existed. Lieut. Hay, therefore, received orders to retire with his garrison as soon as it became dark. This he did without a shot being fired at him. His casualties were one man killed and two wounded, one severely.

The water supply now became a cause of considerable anxiety. It was apparent that the animals could not be again watered at a distance from the fort, the watering-place being commanded by the Boers. On the 17th the Boers drove off the whole of the cattle, and it now became a question whether the horses and mules could be kept. On the 19th December, the horses and mules had been forty-eight hours without water, and the supply for the troops was nearly at an end. Shortly after dark one of the storms common to this country came on, and enough water was caught to water the horses and mules, and supply the troops until the 21st. On the 21st December the well still showed no signs of yielding a sufficient supply of water, although sunk to a depth of thirty feet. The horses and mules had been thirty-six hours without water, and evidently could not hold out much longer. They were therefore turned adrift, and as they galloped off to water were driven off by the enemy. Luckily it rained towards the afternoon, and enough water was caught to last another three days. As the original well showed still no signs of yielding water, a second one was started, which proved more successful than the first. Good water was found in abundance at about fifteen feet. The old well was therefore abandoned.

On the 24th December, the whole of the women and children left the fort and returned to the town, with the exception of Chevalier

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Forsmann and his family, Dr. Sketchley and his wife, and three brothers, English farmers, Nelson by name.

Two children had been hit during the day: one was killed. Up to the 1st January, 1881, the enemy contented themselves with keeping up a dropping fire on the fort all day and night. Wherever they appeared in masses Artillery fire was opened upon them, with the invariable effect of silencing their fire at that particular spot; but, as before stated, the line occupied by the enemy was so long (nearly three-quarters of a mile), that it was impossible, with a limited supply of ammunition and only two guns, to silence them altogether. The enemy, however, were prevented from massing in any large numbers. The interval between the 19th and 31st December had been employed in strenthening the parapets and making sanitary arrangements in the fort. The tents were cut up to make sand-bags, with the exception of a few kept for the use of the sick.

On the 1st of January the Boers made their second general attack on the fort. It commenced at daybreak, when they opened fire with a 3-pr. smooth-bore, firing a leaden projectile weighing about 5 lbs. The fire of this gun was supported by musketry fire from the whole line. They occupied the cemetery, but were soon silenced by Artillery fire. The enemy's gun, which occupied a position on the left flank of their line of attack, fired twenty rounds, several coming through the parapet and falling inside the fort. It was eventually silenced by Artillery fire from the fort. The fire slackened about eight o'clock, and the normal desultory firing was kept up for the remainder of the day.

On the 3rd January, all powder and ammunition was taken from the magazine and destroyed, only such ammunition being kept as could be of use. From this date the magazine was occupied as an outpost, in order to counteract the occupation of the cemetery by the enemy. In the afternoon of the 3rd the enemy opened fire on the magazine with their gun, which they had traversed behind a house from the fire of our guns. We opened fire on it with both guns, wrecking the house, dismounting their gun, and destroying the parapet behind which they were firing. The fire was directed solely against the magazine: twenty-one rounds were fired, four hitting the magazine and penetrating. The range was about 500 yards.

The enemy from this date set to work in earnest to sap up to the fort, and, although harassed as much as possible by Artillery and Infantry fire, continued to progress steadily. On the night of the 7th, a small party of men, under Lieut. Lindsell, R.S.F., assaulted the graveyard, but found it so strongly occupied that, after reaching the wall and firing two or three volleys, they were obliged to retire on the magazine. Their retreat was covered by Artillery and Infantry fire from the fort.

On the 21st January the enemy, who had been steadily sapping to about 300 yards distance on the right, and about the same distance on the left, developed their attack still further by two saps, one to the right rear, and one to the left rear, about 400 yards in rear of the magazine. These saps threatened our rear and necessitated

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further traversing. On the 22nd, the enemy made a third detached sap, commanding the rear of the fort and about 250 yards from it. This sap was assaulted by a small party gallantly led by Lieut. Hay, who took the place in two rushes, driving the enemy out, wounding four or five, and taking four prisoners. The remainder, to the number of thirty, fled, under the cover of the long grass into the south end of the town. To cover the assaulting party a heavy fire was kept up both by the Infantry and the guns. Lieut. Hay lost two of his party going and one coming back. A third man subsequently died of his wounds. The result of this sortie was most successful; it enabled us to get back four of our prisoners, taken at the surrender of the Landrost's office, in exchange for the captured Boers. From these men we learnt that troops had left England and India, and that relief might be hoped for,—a hope, however, which was destined never to be fulfilled.

From the day of the surrender of the Landrost's office till the 23rd January, the British flag had not waved at Potchefstroom, there being no Union Jack with the troops. On the 23rd January the Union Jack was hoisted on the parapet for the first time, and was loudly cheered by the garrison. Its composition is worthy of note: the white and red lining of the cloaks of a Subaltern and Sergeant of Artillery, and a blue serge coat kindly sacrificed by one of the Infantry Officers.

On January 29th the enemy again opened fire with their gun, this time from a position in front of the fort and 500 yards from it. Although shell after shell was burst near it, we failed to silence it, and it was not till after the siege that the reason was apparent. The Boers loaded this gun behind a small house filled with sacks of earth, which effectually protected them from our shell, and only ran it round the corner to fire. The bushes were so thick on each side of the house that they entirely prevented the movements of the enemy being seen. From this time until the 10th March the enemy fired their gun almost every day at the fort, doing little or no damage. From want of ammunition, more especially of common shell, it could not always be answered by Artillery fire. On one occasion a shot from the enemy's gun came into the embrasure while the detachment were in action, killing the number sponging out, and wounding severely the number serving the vent.

Until the 15th February, beyond closely investing the fort, preventing any communications and keeping up a constant fire day and night, the Boers developed their attack no further. At this time the Boers commenced to surround the fort at night with a cordon of picquets. Lieut. Lean, Commissary Dunne and myself went out on successive nights with small parties and tried to intercept these picquets; but we were never able to get near any of them. On the last occasion an attempt was made to cut our party off, but they got back to camp all right.

On the 15th February the enemy showed signs of renewed vigour in the attack. During the night they brought up a quantity of wool bags and sapped at a rapid rate towards the magazine. To counteract this attack a counter sap was commenced from the magazine which had

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the effect of keeping the enemy's sap further from it. Up to the 7th March the enemy sapped from 30 to 20 yards a night towards the magazine. On reaching a point just in rear of it, and 100 yards from it, which enfiladed the sap connecting the magazine with the fort, they built an earthwork of bags of earth about 12 feet high, and 6 or 7 feet thick at the top. This fort commanded the magazine. From information received it was daily expected that an assault would be made on the fort, commencing with an attack on the magazine; and we subsequently discovered that this was the design of the Boers.

During the night of the 9th March the Boers made a line of shelter trenches, with a small earthwork in the middle, about 600 yards in rear of the fort. These shelter trenches took the front face of the fort in reverse.

At daybreak on the 10th they opened fire with their gun from this earthwork, and during the day fired 83 shots at the fort, most of which took effect, but doing little or no damage. The Boers supported the fire of their gun by heavy musketry fire, which only ceased with the light.

On the following day the enemy again opened fire, firing 52 rounds during the day. One ball came into a tent full of wounded men, tore one man's arm so severely as to necessitate amputation, and hit another wounded man so severely that he died from the effects a few days afterwards.

The whole of the garrison now daily looked out for the long expected column of relief; and it became apparent that unless it came in a very few days, we should be obliged to capitulate for want of food. Provisioned with only one month's meat and six weeks' bread stuff, the garrison had held out for three months with the assistance of mealies, which were eventually the only food left and which were now beginning to fail us, being half rotten from exposure and wet. For three months the men had been exposed to the effects of the weather, with only such cover as they could obtain from shelter made of waterproof sheets, &c. One day they were baked by the sun: the next they were soaked with the rain which fell in torrents for about two months. Often the men had to sleep in water, and this combined with want of food had necessarily produced dysentery and enteric fever, from which officers and men suffered alike. Three cases of scurvy had broken out, and thus with sickness and starvation staring him in the face Colonel Winsloe determined to propose terms to the Boer Commander. Eight bags of rotten mealies were the sole food left for a garrison of over 200 souls including civilians.

Colonel Winsloe attended by his adjutant, Lieut. Browne, R.S.F., myself, and Surgeon Wallis, A.M.D. met the Boer General and his Staff in a marquee pitched between the positions held by H. M. troops and the Burgher forces of the S. African Republic. Terms were arranged for the evacuation of all positions held by H.M. troops. These conditions were signed by Colonel Winsloe, General Cronjie and the whole of the officers present on the 21st March, the 96th day of the siege. On the following Wednesday Colonel Winsloe and the whole of his garrison marched out with the honours of war, their flag

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flying and bugles playing, and laid down their arms, being received by General Cronjie and the Burgher forces under his command with shouldered arms. We then marched into the Orange Free State, the troops retaining their flag, and officers their swords.

It is impossible to conclnde an account of the Siege of Potchefstroom without placing on record that the moment hostilities ceased every assistance was given by the Boers in procuring food for the garrison and medicine and comforts for the sick and wounded. The officers of the garrison were entertained at dinner by General Cronjie and the officers of the Boer forces. On the day of the evacuations every mark of respect was shown by the Boers to H. M. troops, and neither by sign nor word was any discourtesy shown them whilst marching through the town. In short, the courtesy shown by the Boers after the cessation of hostilities to those who a few days before had been their enemies, could not have been exceeded by any European nation.

There are, however, several instances where the Boers did not follow the rules of civilized warfare, and these doubtless will receive the investigations they require. Although twice remonstrated with by Colonel Winsloe, the Boers during the siege continued the use of explosive bullets, one man being severely wounded by one. While their own and our white flags were flying, they wounded severely a man at the gaol. The Boers forced natives to work in the saps exposed to our fire, and even armed natives against us. Further they forced white men to work in the trenches, one man by name Findlay being killed by us while so employed. Of the Boer casualties during the siege it is impossible to form any accurate estimate. They themselves will only confess to one or two killed and twenty wounded. There can, however, be little doubt that their total in killed and wounded was little short of 200, as many as fifteen burials being known to have taken place at one time. The Boer leaders in Potchefstroom, as in other places, were careful to conceal their losses from their men, and until they dispersed to their homes, the Boers themselves did not know their true loss.

In forming an opinion upon the seige of Potchefstroom, it must be borne in mind that its position as a garrison was unique. Pretoria was provisioned for almost any length of time, and no Boer force ever came within five or six miles of it; Standerton and Rustenberg had also provisions and well built forts. Potchefstroom had neither, and it may be safely said that none of these places were so persistently besieged as Potchefstroom. The anxiety to obtain possession of the guns fully accounted for the persistency shown by the Boers in the attack.

The number of Boers at the commencement of the attack was about 800; in the beginning of January this number increased to 1,500; and from this time the enemy were never in less numbers than 400.

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THE GARRISON OF POTCHEFSTROOM.

Commanding Officer: Lieut.-Colonel Winsloe, 2/21st Royal Scots Fusiliers.
Officer Commanding R.A.: Major C. Thornhill, R.A.
Medical Officer: Surgeon R. Wallis, A.M.D.
Commissariat Officer: D.-A.-C.-G. W. A. Dunne.

Corps.	Officers.	N.-C. Officers and Men.	Total.
Royal Artillery	2	43	45
Royal Scots Fusiliers	6	125	131
Mounted Infantry	—	24	24
Army Service Corps	1	7	8
Army Hospital Corps	1	4	5
Total	10	203	213

GENERAL CASUALTIES.

Nature of Casualty.	Officers.	N.-C. Officers.	Men.	Total.
Killed and died of wounds ...	1	2	19	22
Died of disease	—	1	3	4
Wounded	5	6	38	49
Total	6	9	60	75

CASUALTIES BY CORPS.

Corps and Rank.	Killed and Died of Wounds.	Died of Disease.	Wounded.	Total.	Grand Total.	Total Strength.
Royal Artillery ... Officers	—	—	1	1	19	45
Royal Artillery ... N.-C. O.'s and men	5	2	11	18		
Royal Scots Fusiliers Officers	1	—	3	4	43	131
Royal Scots Fusiliers N.-C. O.'s and men	11	2	25	38		
Mounted Infantry... N.-C. O.'s and men	5	—	5	10	10	24
Army Service Corps Officers	—	—	—	—	1	8
Army Service Corps N.-C. O.'s and men	—	—	1	1		
Army Hospital Corps Officers	—	—	1	1	3	5
Army Hospital Corps N.-C. O.'s and men	—	—	2	2		
Total	22	4	49	75	75	213

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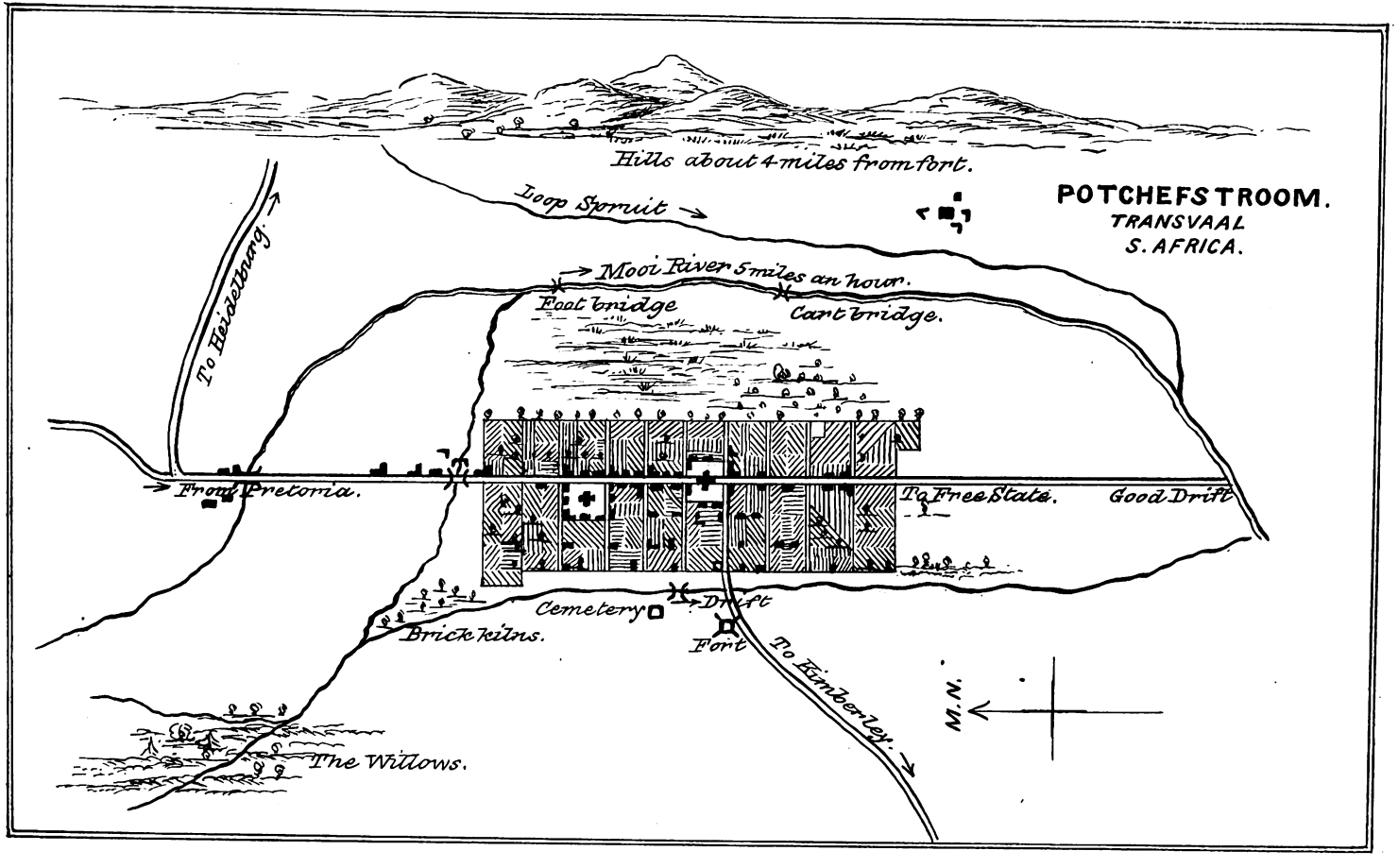

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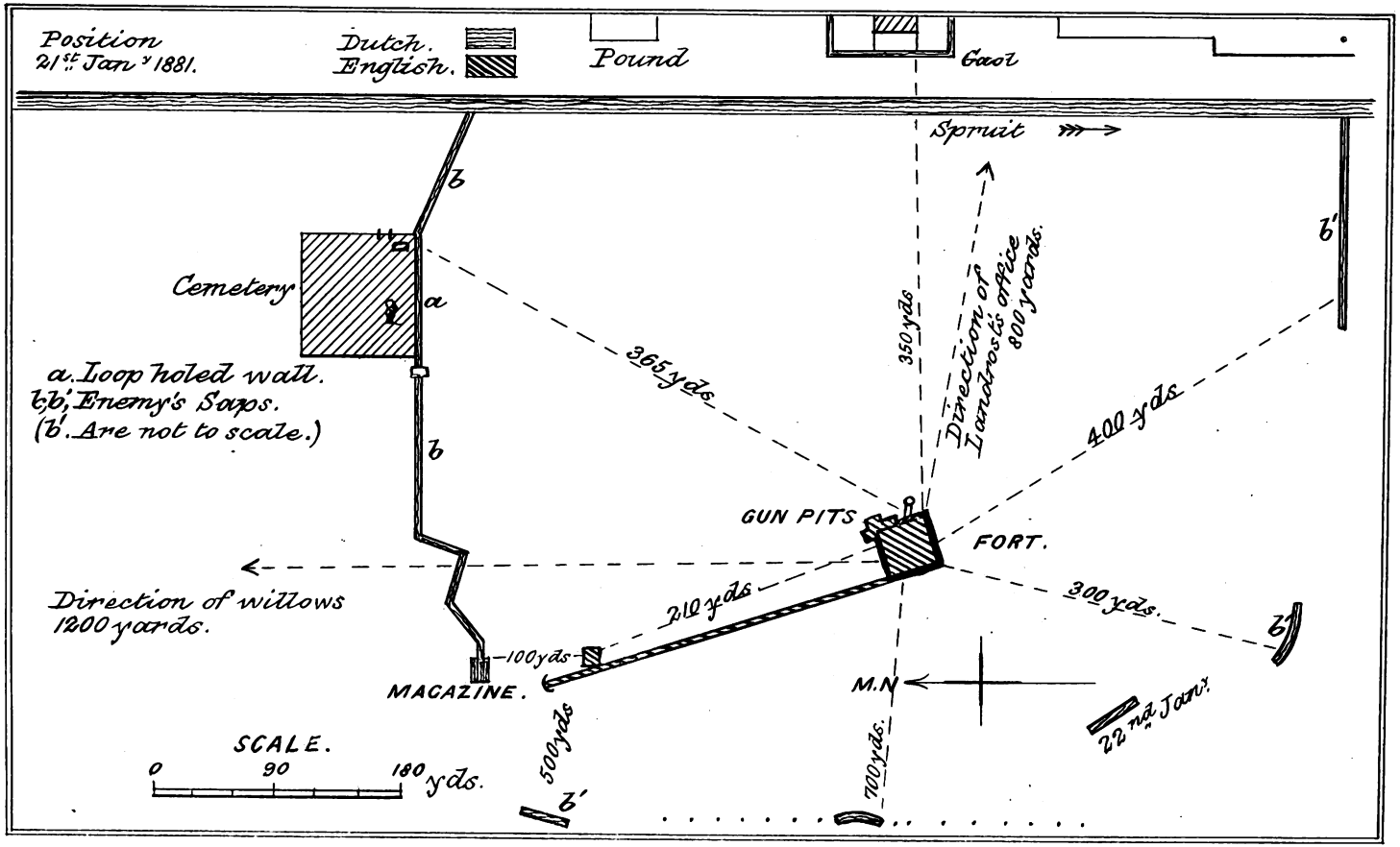

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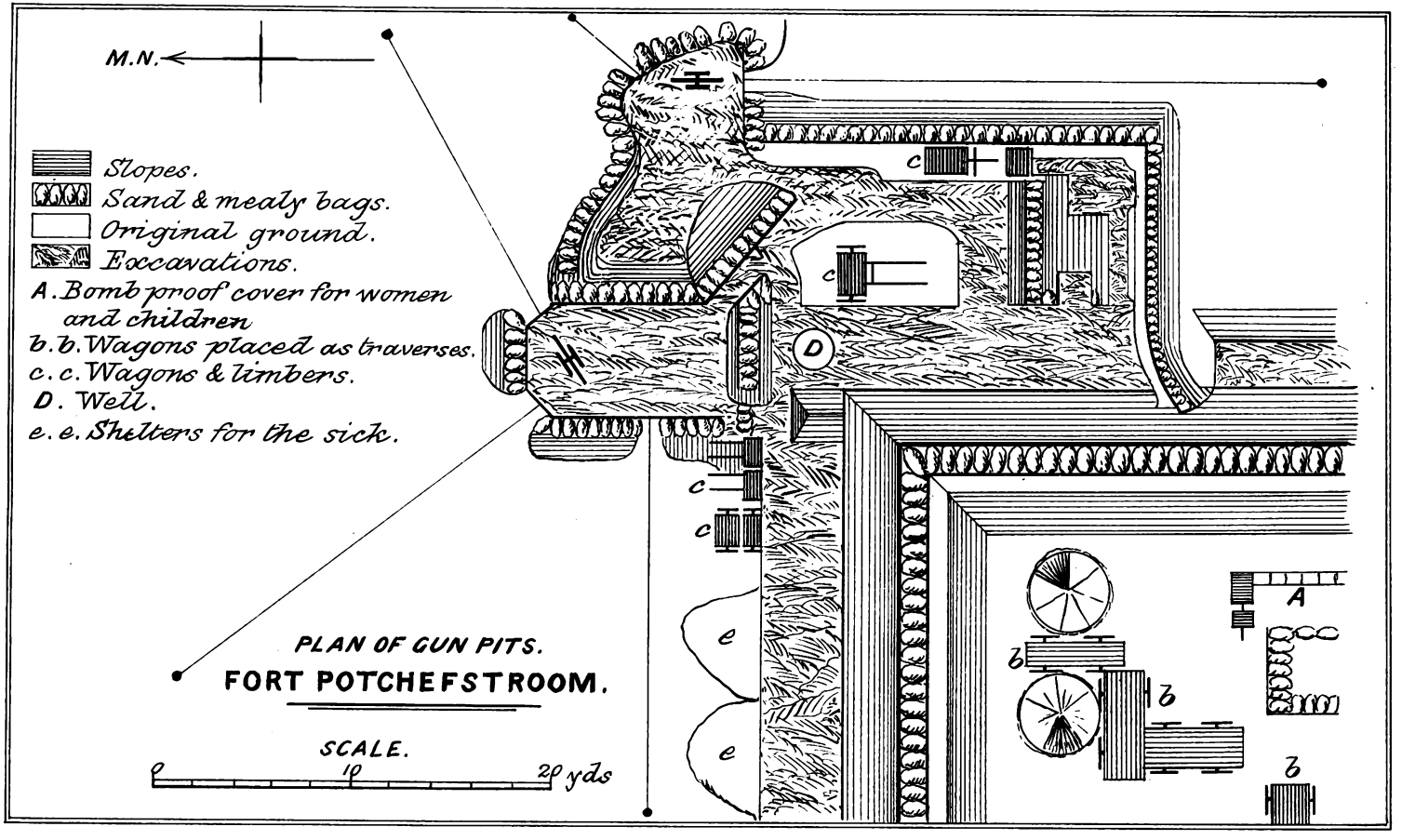

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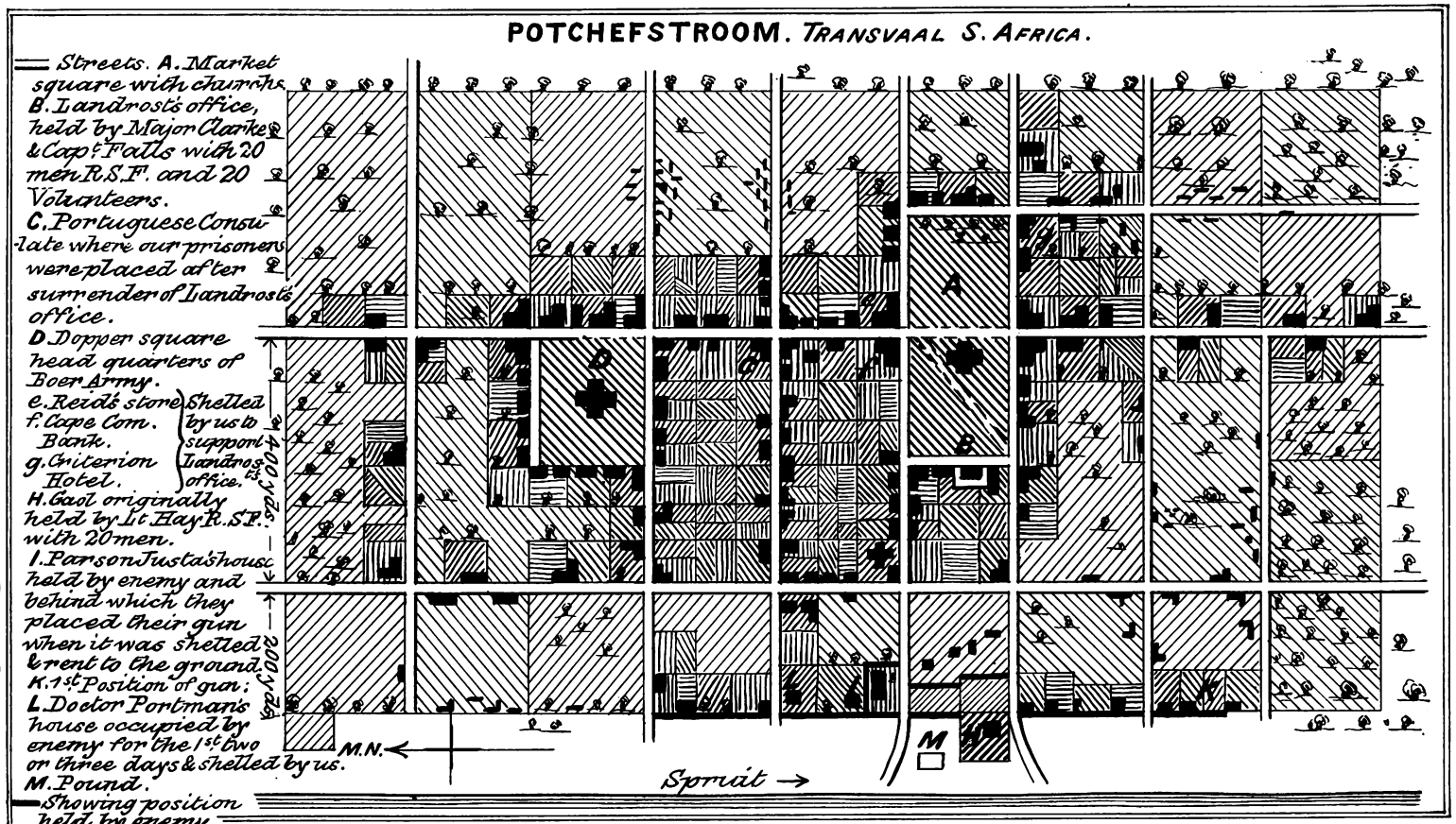
POTCHEFSTROOM. TRANSVAAL S. AFRICA.


Streets. A. Market square with churches.
B. Landrost's office, held by Major Clarke & Capt Falls with 20 men R.S.F. and 20 Volunteers.
C. Portuguese Consulate where our prisoners were placed after surrender of Landrost's office.
D. Dopper square head quarters of Boer Army.
e. Reid's store
f. Cape Com. Bank.
g. Criterion Hotel.
Shelled by us to support Landrost's office.
H. Gaol originally held by Lt Hay R.S.F. with 20 men.
I. Parson Justa's house held by enemy and behind which they placed their gun when it was shelled & sent to the ground.
K. 1st Position of gun.
L. Doctor Portman's house occupied by enemy for the 1st two or three days & shelled by us.
M. Pound.
Showing position held by enemy.
400 Yds.
200 Yds.
M.N.
Spruit
M
A
B
D
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K
L

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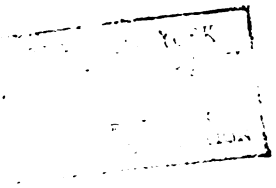

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ON THE

MOTION OF A PROJECTILE IN A RESISTING MEDIUM,

(*Continued from* p. 598, *Vol. XI.*)

BY

A. G. GREENHILL, M.A.,

(*Professor of Mathematics to the Advanced Class of Artillery Officers.*)

The coefficient of x on the right hand side of this equation may be thrown into a real form by means of the cubic transformation; for

$$\frac{1}{2}\frac{d}{da}\log(1-\operatorname{cn}\omega a)(1-\operatorname{cn}\omega^2 a)\,\Theta\omega a\,\Theta\omega^2 a$$

$$=\frac{d}{da}\log(\operatorname{cn}\tfrac{1}{3}i\sqrt{3}a-\operatorname{cn}\tfrac{1}{2}a)\,\Theta\tfrac{1}{2}a\,\Theta\tfrac{1}{2}i\sqrt{3}a$$

$$=\frac{d}{da}\log\{1-\operatorname{cn}\tfrac{1}{2}a\operatorname{cn}(\tfrac{1}{2}\sqrt{3}a,k')\}\,\Theta\tfrac{1}{2}a.\exp.\frac{3\pi(2K-a)^2}{16KK'}\Theta(\tfrac{1}{2}\sqrt{3}a,k')$$

$$=-\frac{3\pi(2K-a)}{8KK'}$$

$$+\frac{d}{da}\log\left\{1-\operatorname{cn}^2\tfrac{1}{2}a\,\frac{1-\dfrac{\operatorname{sn}^2\frac{1}{2}a}{\operatorname{sn}^2(K-\frac{4}{3}iK')}}{1-k^2\operatorname{sn}^2\frac{4}{3}iK'\operatorname{sn}^2\frac{1}{2}a}\right\}\Theta^2\tfrac{1}{2}a\Theta(\tfrac{1}{2}a+\tfrac{4}{3}iK')\Theta(\tfrac{1}{2}a-\tfrac{4}{3}iK')$$

$$=-\frac{3\pi(2K-a)}{8KK'}$$

$$+\frac{d}{da}\log\left(1-k^2\operatorname{sn}^2\tfrac{4}{3}iK'\operatorname{sn}^2\tfrac{1}{2}a-\operatorname{cn}^2\tfrac{1}{2}a+\operatorname{sn}^2\tfrac{1}{2}a\operatorname{cn}^2\tfrac{1}{2}a\,\frac{\operatorname{dn}^2\frac{4}{3}iK'}{\operatorname{cn}^2\frac{4}{3}iK'}\right)\Theta^4\tfrac{1}{2}a$$

$$=-\frac{3\pi(2K-a)}{8KK'}+\frac{d}{da}\log\operatorname{sn}^2\tfrac{1}{2}a\operatorname{dn}^2\tfrac{1}{2}a\,\Theta^4\tfrac{1}{2}a$$

$$=-\frac{3\pi(2K-a)}{8KK'}+\frac{d}{da}\log(1-\operatorname{cn}a)\,\Theta a$$

$$=-\frac{3\pi(2K-a)}{8KK'}+2\frac{d}{da}\log\Theta_1\tfrac{1}{2}a\,\Theta_3\tfrac{1}{2}a;$$

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so that the coefficient of x

$$= -\frac{3\pi(2K-a)}{8KK'} + \frac{3}{2}\frac{d}{da}\log(1-\operatorname{cn} a)\,\Theta a$$

$$= -\frac{3\pi(2K-a)}{8KK'} + 3\frac{d}{da}\log\Theta_1\tfrac{1}{2}a\;\Theta_3\tfrac{1}{2}a$$

Using oblique co-ordinates, the tangent at the origin as the axis of x', and the vertical downwards through the origin as the axis of y', then

$$y' = ax - y,$$

and

$$x' = x\sqrt{(1+a^2)}$$

$$= \frac{w^2}{g}\frac{\sqrt[4]{3}\,\sqrt{(1+a^2)}}{(4+a^2)^{\frac{1}{2}}(4+4a^2)^{\frac{1}{4}}}\,x$$

$$= \frac{w^2}{g}\frac{\sqrt[4]{3}}{2}\left(\frac{4+4a^2}{4+a^2}\right)^{\frac{1}{8}}x$$

$$= \frac{w^2}{g}\frac{\sqrt[4]{3}}{2\sqrt{b}}x,$$

or

$$x = \frac{2\sqrt{b}}{\sqrt[4]{3}}\frac{gx'}{w^2}$$

$$= \sqrt[4]{\frac{2}{3}}\sqrt{\left(\frac{1-\operatorname{cn} a}{k'+k\operatorname{cn} a}\right)}\frac{gx'}{w^2}.$$

To express the time t in the trajectory in terms of x or x, taking the expression given on p. 139, Vol. XI., "Proceedings of the R.A. Institution,"

$$u = w\sqrt[4]{3}\,\frac{\sqrt{(4+a^2)}}{1+a^2}\,\frac{1-\operatorname{cn} x}{1-\operatorname{cn} a}\,\frac{k'+k\operatorname{cn} a}{k'+k\operatorname{cn} x}\quad(X+A),$$

then, since

$$u = \frac{dx}{dt},$$

therefore

$$\frac{g}{w}\frac{dt}{dx} = \frac{g}{w}\frac{dt}{dx}\frac{dx}{dx}$$

$$= \frac{g}{w^2}\frac{1+a^2}{\sqrt[4]{3}\,\sqrt{(4+a^2)}}\frac{1-\operatorname{cn} a}{k'+k\operatorname{cn} a}\frac{k'+k\operatorname{cn} x}{1-\operatorname{cn} x}\frac{1}{X+A}\frac{w^2}{g}\frac{\sqrt[4]{3}}{(4+a^2)^{\frac{1}{2}}(4+4a^2)^{\frac{1}{4}}}$$

$$= \frac{1}{4}\left(\frac{4+4a^2}{4+a^2}\right)^{\frac{1}{8}}\frac{1-\operatorname{cn} a}{k'+k\operatorname{cn} a}\frac{k'+k\operatorname{cn} x}{1-\operatorname{cn} x}\frac{1}{X+A}$$

$$= 2c\,\frac{k'+k\operatorname{cn} x}{1-\operatorname{cn} x}\,\frac{X-A}{X^2-A^2}$$

$$= c\,\frac{(k'+k)^3}{c^3+k^3}\,\frac{(k'+k\operatorname{cn} x)\operatorname{sn} x\operatorname{dn} x - (k'+k\operatorname{cn} x)(1-\operatorname{cn} x)^2\dfrac{\operatorname{sn} a\operatorname{dn} a}{(1-\operatorname{cn} a)^2}}{(\operatorname{cn} x-\operatorname{cn} a)(\operatorname{cn} x-\operatorname{cn}\omega a)(\operatorname{cn} x-\operatorname{cn}\omega^2 a)}.$$

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This fraction has a quotient

$$-c\,\frac{(k'+k)^3}{c^3+k^3}\quad\frac{k\ \mathrm{sn\ a\ dn\ a}}{(1-\mathrm{cn\ a})^2}$$

which can easily be proved to be

$$=\frac{1}{2}\frac{d}{da}\{\log(1-\mathrm{cn\ a})+\omega\log(1-\mathrm{cn}\ \omega a)+\omega^2\log(1-\mathrm{cn}\ \omega^2 a)\}$$

The remainder of the fraction being split up into partial fractions of the form,

$$\frac{A\ \mathrm{sn\ x\ dn\ x}-A'}{\mathrm{cn\ x}-\mathrm{cn\ a}}$$

$$+\frac{B\ \mathrm{sn\ x\ dn\ x}-B'}{\mathrm{cn\ x}-\mathrm{cn}\ \omega a}$$

$$+\frac{C\ \mathrm{sn\ x\ dn\ x}-C'}{\mathrm{cn\ x}-\mathrm{cn}\ \omega^2 a};$$

then, as before, it can easily be proved that

$$A=\tfrac{1}{2},\quad A'=\tfrac{1}{2}\ \mathrm{sn\ a\ dn\ a};$$

$$B=\tfrac{1}{2}\omega^2,\quad B'=\tfrac{1}{2}\omega^2\ \mathrm{sn}\ \omega a\ \mathrm{dn}\ \omega a;$$

$$C=\tfrac{1}{2}\omega,\quad C'=\tfrac{1}{2}\omega\ \mathrm{sn}\ \omega^2 a\ \mathrm{dn}\ \omega^2 a.$$

Therefore $\dfrac{gt}{w}$

$$=\frac{1}{2}\ \mathrm{x}\ \frac{d}{da}\{\log(1-\mathrm{cn\ a})+\omega\log(1-\mathrm{cn}\ \omega a)+\omega^2\log(1-\mathrm{cn}\ \omega^2 a)\}$$

$$+\frac{1}{2}\int_0^{\mathrm{x}}\frac{\mathrm{sn\ x\ dn\ x}-\mathrm{sn\ a\ dn\ a}}{\mathrm{cn\ x}-\mathrm{cn\ a}}\mathrm{dx}$$

$$+\frac{1}{2}\omega^2\int_0^{\mathrm{x}}\frac{\mathrm{sn\ x\ dn\ x}-\mathrm{sn}\ \omega a\ \mathrm{dn}\ \omega a}{\mathrm{cn\ x}-\mathrm{cn}\ \omega a}\mathrm{dx}$$

$$+\frac{1}{2}\omega\int_0^{\mathrm{x}}\frac{\mathrm{sn\ x\ dn\ x}-\mathrm{sn}\ \omega^2 a\ \mathrm{dn}\ \omega^2 a}{\mathrm{cn\ x}-\mathrm{cn}\ \omega^2 a}\mathrm{dx}$$

$$=\frac{1}{2}\ \mathrm{x}\ \frac{d}{da}\{\log(1-\mathrm{cn\ a})\,\Theta a+\omega\log(1-\mathrm{cn}\ \omega a)\,\Theta\omega a+\omega^2\log(1-\mathrm{cn}\ \omega^2 a)\Theta\omega^2 a\}$$

$$-\frac{1}{2}\log\frac{1-\mathrm{cn\ (a+x)}}{1-\mathrm{cn\ a}}\quad\frac{\Theta(\mathrm{a+x})\,\Theta\mathrm{o}}{\Theta\mathrm{a}\,\Theta\mathrm{x}}$$

$$-\frac{1}{2}\omega^2\log\frac{1-\mathrm{cn}\ (\omega a+\mathrm{x})}{1-\mathrm{cn}\ \omega a}\quad\frac{\Theta(\omega a+\mathrm{x})\,\Theta\mathrm{o}}{\Theta\omega a\,\Theta\mathrm{x}}$$

$$-\frac{1}{2}\omega\log\frac{1-\mathrm{cn}\ (\omega^2 a+\mathrm{x})}{1-\mathrm{cn}\ \omega^2 a}\quad\frac{\Theta(\omega^2 a+\mathrm{x})\,\Theta\mathrm{o}}{\Theta\,\omega^2 a\,\Theta\mathrm{x}}$$

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$$= x \frac{d}{da} (\log \Theta_{1\frac{1}{2}}a \, \Theta_{3\frac{1}{2}}a + \omega \log \Theta_{1\frac{1}{2}}a \, \Theta_{3\frac{1}{2}}\omega a + \omega^2 \log \Theta_{1\frac{1}{2}}\omega^2 a \, \Theta_{3\frac{1}{2}}\omega^2 a)$$

$$- \log \frac{\Theta_{1\frac{1}{2}}(a+x)}{\Theta_{1\frac{1}{2}}a} \quad \frac{\Theta_{3\frac{1}{2}}(a+x)}{\Theta_{3\frac{1}{2}}a}$$

$$-\omega^2 \log \frac{\Theta_{1\frac{1}{2}}(\omega a+x)}{\Theta_{1\frac{1}{2}}\omega a} \quad \frac{\Theta_{3\frac{1}{2}}(\omega a+x)}{\Theta_{3\frac{1}{2}}\omega a}$$

$$-\omega \log \frac{\Theta_{1\frac{1}{2}}(\omega^2 a+x)}{\Theta_{1\frac{1}{2}}\omega^2 a} \quad \frac{\Theta_{3\frac{1}{2}}(\omega^2 a+x)}{\Theta_{3\frac{1}{2}}\omega^2 a}.$$

Consequently $\frac{g}{w^2}(ax-y) + \frac{gt}{w}$ can be expressed by means of Θ functions with real arguments.

We might have seen immediately the fact proved on pages 590 to 594, Vol. XI., that

if $x = a$ when $z = 1$,

then $x = \omega a$ when $z = \omega$,

and $x = \omega^2 a$ when $z = \omega^2$,

from the fact that—(p. 133, vol. XI.)

$$\int_z^\infty \frac{dz}{\sqrt{(z^3 - b^3)}} = \frac{x}{\sqrt{(b\sqrt{3})}},$$

and then

$$z = b + b\sqrt{3}\,\frac{1 + \operatorname{cn} x}{1 - \operatorname{cn} x}$$

$$= \phi(x) \quad \text{suppose.}$$

Then if $y = \omega z$,

$$\int_y^\infty \frac{dy}{\sqrt{(y^3 - b^3)}} = \int_z^\infty \frac{\omega\, dz}{\sqrt{(z^3 - b^3)}} = \frac{\omega x}{\sqrt{(b\sqrt{3})}},$$

and $y = \phi(\omega x)$

or $\omega\phi(x) = \phi(\omega x)$;

so that the factors of $z^3 - 1$, viz., $\phi(x) - \phi(a)$, $\phi(x) - \omega\phi(a)$, $\phi(x) - \omega^2\phi(a)$ becomes $\phi(x) - \phi(a)$, $\phi(x) - \phi(\omega a)$, $\phi(x) - \phi(\omega^2 a)$.

The values of Θ, Θ_1, Θ_2, Θ_3 have been tabulated, under the superintendence of Mr. J. W. L. Glaisher, for real values of the argument, but, as our expressions contain imaginary arguments as well, we must employ the expansions that were used for the calculation: these expansions are to be found on p. 123 of Enneper's *Elliptic Functions*; and from that,—

$$\log \frac{\Theta_{1\frac{1}{2}}(a + x)}{\Theta_{1\frac{1}{2}}a} = \log \frac{\theta_1 \frac{\pi}{4K}(a + x)}{\theta_1 \frac{\pi a}{4K}}$$

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$$= \log \frac{\sin \frac{\pi}{4K}(a+x)}{\sin \frac{\pi a}{4K}} + \sum_{r=1}^{r=\infty} \frac{2}{r} \frac{q^{2r}}{1-q^{2r}} \left\{ \cos \frac{\pi r a}{2K} - \cos \frac{\pi r}{2K}(a+x) \right\};$$

$$\log \frac{\Theta_3 \frac{1}{2}(a+x)}{\Theta_3 \frac{1}{2} a} = \log \frac{\theta_3 \frac{\pi}{4K}(a+x)}{\theta_3 \frac{\pi a}{4K}}$$

$$= \sum_{r=1}^{r=\infty} \frac{2}{r} \frac{(-q)^r}{1-q^{2r}} \left\{ \cos \frac{\pi r a}{2K} - \cos \frac{\pi r}{2K}(a+x) \right\};$$

and therefore

$$\log \frac{\Theta_1 \frac{1}{2}(a+x)}{\Theta_1 \frac{1}{2} a} \cdot \frac{\Theta_3 \frac{1}{2}(a+x)}{\Theta_3 \frac{1}{2} a}$$

$$= \log \frac{\sin \frac{\pi}{4K}(a+x)}{\sin \frac{\pi a}{4K}} + \sum \frac{2}{r} \frac{(-q)^r}{1-(-q)^r} \left\{ \cos \frac{\pi r a}{2K} - \cos \frac{\pi r}{2K}(a+x) \right\}$$

$$= \log \frac{\sin \frac{\pi}{4K}(a+x)}{\sin \frac{\pi a}{4K}} + \sum \frac{4}{r} \frac{(-q)^r}{1-(-q)^r} \sin \frac{\pi r x}{4K} \sin \frac{\pi r}{4K}(2a+x).$$

Also

$$\frac{d}{da} \log \Theta_1 \tfrac{1}{2} a = \frac{d}{da} \log \theta_1 \frac{\pi a}{2K}$$

$$= \frac{\pi}{4K} \cot \frac{\pi a}{4K} + \frac{\pi}{K} \sum \frac{q^{2r}}{1-q^{2r}} \sin \frac{\pi r a}{2K};$$

and

$$\frac{d}{da} \log \Theta_3 \tfrac{1}{2} a = \frac{d}{da} \log \theta_3 \frac{\pi a}{4K}$$

$$= \frac{\pi}{K} \sum \frac{(-q)^r}{1-q^{2r}} \sin \frac{\pi r a}{2K};$$

and therefore

$$\frac{d}{da} \log \Theta_1 \tfrac{1}{2} a \, \Theta_3 \tfrac{1}{2} a$$

$$= \frac{\pi}{4K} \cot \frac{\pi a}{4K} + \frac{\pi}{K} \sum \frac{(-q)^r}{1-(-q)^r} \sin \frac{\pi r a}{2K}.$$

With the modulus $k = \sin 15°$,

$$q = e^{-\pi \frac{K'}{K}} = e^{-\pi\sqrt{3}} = 0{\cdot}00433342,$$

and in working to 8 places of decimals, two terms at most of the above series need only be retained.

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Therefore $\frac{g}{w^2}(ax-y)$

$$=\frac{\pi x}{4K}\left(\cot\frac{\pi a}{4K}+\omega\cot\frac{\pi\omega a}{4K}+\omega^2\cot\frac{\pi\omega^2 a}{4K}\right)$$

$$+\frac{\pi x}{K}\Sigma\frac{(-q)^r}{1-(-q)^r}\left(\sin\frac{\pi r a}{2K}+\omega\sin\frac{\pi r\omega a}{2K}+\omega^2\sin\frac{\pi r\omega^2 a}{2K}\right)$$

$$-\log\frac{\sin\frac{\pi}{4K}(a+x)}{\sin\frac{\pi a}{4K}}-\omega\log\frac{\sin\frac{\pi}{4K}(\omega a+x)}{\sin\frac{\pi\omega a}{4K}}-\omega^2\log\frac{\sin\frac{\pi}{4K}(\omega^2 a+x)}{\sin\frac{\pi\omega^2 a}{4K}}$$

$$-\Sigma\frac{4}{r}\frac{(-q)^r}{1-(-q)^r}\sin\frac{\pi r x}{4K}$$

$$\left\{\sin\frac{\pi r}{4K}(2a+x)+\omega\sin\frac{\pi r}{4K}(2\omega a+x)+\omega^2\sin\frac{\pi r}{4K}(2\omega^2 a+x)\right\};$$

or this may be written,—

$$\frac{g}{w^2}(ax-y)=-\frac{3\pi(2K-a)x}{8KK'}$$

$$+\frac{3\pi x}{4K}\cot\frac{\pi a}{4K}+\frac{3\pi x}{K}\Sigma\frac{(-q)^r}{1-(-q)^r}\sin\frac{\pi r a}{2K}$$

$$-\log\frac{\sin\frac{\pi}{4K}(a+x)}{\sin\frac{\pi a}{4K}}-\omega\log\frac{\sin\frac{\pi}{4K}(\omega a+x)}{\sin\frac{\pi\omega a}{4K}}-\omega^2\log\frac{\sin\frac{\pi}{4K}(\omega^2 a+x)}{\sin\frac{\pi\omega^2 a}{4K}}$$

$$-\Sigma\frac{4}{r}\frac{(-q)^r}{1-(-r)}\sin\frac{\pi r x}{4K}$$

$$\left\{\sin\frac{\pi r}{4K}(2a+x)+\omega\sin\frac{\pi r}{4K}(2\omega a+x)+\omega^2\sin\frac{\pi r}{4K}(2\omega^2 a+x)\right\}.$$

Also $\frac{gt}{w}$

$$=\frac{\pi x}{4K}\left(\cot\frac{\pi a}{4K}+\omega^2\cot\frac{\pi\omega a}{4K}+\omega\cot\frac{\pi\omega^2 a}{4K}\right)$$

$$+\frac{\pi x}{K}\Sigma\frac{(-q)^r}{1-(-q)^r}\left(\sin\frac{\pi r a}{2K}+\omega^2\sin\frac{\pi r\omega a}{2K}+\omega\sin\frac{\pi r\omega^2 a}{2K}\right)$$

$$-\log\frac{\sin\frac{\pi}{4K}(a+x)}{\sin\frac{\pi a}{4K}}-\omega^2\log\frac{\sin\frac{\pi}{4K}(\omega a+x)}{\sin\frac{\pi\omega a}{4K}}-\omega\log\frac{\sin\frac{\pi}{4K}(\omega^2 a+x)}{\sin\frac{\pi\omega^2 a}{4K}}$$

$$-\Sigma\frac{4}{r}\frac{(-q)^r}{1-(-q)^r}\sin\frac{\pi r x}{4K}$$

$$\left\{\sin\frac{\pi r}{4K}(2a+x)+\omega^2\sin\frac{\pi r}{4K}(2\omega a+x)+\omega\sin\frac{\pi r}{4K}(2\omega^2 a+x)\right\}.$$

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A further reduction is still required in order to exhibit these results in a real form.

For $$\sin(\omega a + x)$$

$$= \sin(-\tfrac{1}{2}a + x + i\tfrac{1}{2}\sqrt{3}a)$$

$$= -\sin(\tfrac{1}{2}a - x)\cosh\tfrac{1}{2}\sqrt{3}a + i\cos(\tfrac{1}{2}a - x)\sinh\tfrac{1}{2}\sqrt{3}a;$$

and therefore

$$\omega\sin(\omega a + x) + \omega^2\sin(\omega^2 a + x)$$

$$= \sin(\tfrac{1}{2}a - x)\cosh\tfrac{1}{2}\sqrt{3}a - \sqrt{3}\cos(\tfrac{1}{2}a - x)\sinh\tfrac{1}{2}\sqrt{3}a;$$

$$\omega^2\sin(\omega a + x) + \omega\sin(\omega^2 a + x)$$

$$= \sin(\tfrac{1}{2}a - x)\cosh\tfrac{1}{2}\sqrt{3}a + \sqrt{3}\cos(\tfrac{1}{2}a - x)\sinh\tfrac{1}{2}\sqrt{3}a.$$

Again, $$\cot\omega a = \frac{\cos\omega a}{\sin\omega a} = \frac{\cos\omega a \sin\omega^2 a}{\sin\omega a \sin\omega^2 a}$$

$$= \frac{-\sin i\sqrt{3}a - \sin a}{\cos i\sqrt{3}a - \cos a}$$

$$= \frac{-i\sinh\sqrt{3}a - \sin a}{\cosh\sqrt{3}a - \cos a}$$

and therefore

$$\omega\cot\omega a + \omega^2\cot\omega^2 a$$

$$= \frac{\sqrt{3}\sinh\sqrt{3}a + \sin a}{\cosh\sqrt{3}a - \cos a},$$

and

$$\omega^2\cot\omega a + \omega\cot\omega^2 a$$

$$= \frac{-\sqrt{3}\sinh\sqrt{3}a + \sin a}{\cosh\sqrt{3}a - \cos a}.$$

Again $$\log\sin(\omega a + x)$$

$$= \log\{-\sin(\tfrac{1}{2}a - x)\cosh\tfrac{1}{2}\sqrt{3}a + i\cos(\tfrac{1}{2}a - x)\sinh\tfrac{1}{2}\sqrt{3}a\}$$

$$= \frac{1}{2}\log\{\sin^2(\tfrac{1}{2}a - x)\cosh^2\tfrac{1}{2}\sqrt{3}a + \cos^2(\tfrac{1}{2}a - x)\sinh^2\tfrac{1}{2}\sqrt{3}a\}$$

$$-i\tan^{-1}\frac{\tanh\tfrac{1}{2}\sqrt{3}a}{\tan(\tfrac{1}{2}a - x)}$$

$$= \frac{1}{2}\log\frac{1}{2}\{\cosh\sqrt{3}a - \cos(a - 2x)\} - i\tan^{-1}\frac{\tanh\tfrac{1}{2}\sqrt{3}a}{\tan(\tfrac{1}{2}a - x)}$$

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and $$\log \frac{\sin(\omega a + x)}{\sin \omega a}$$

$$= \frac{1}{2} \log \frac{\cosh \sqrt{3}a - \cos(a-2x)}{\cosh \sqrt{3}a - \cos a} - i \tan^{-1} \frac{\tanh \frac{1}{2}\sqrt{3}a}{\tan(\frac{1}{2}a - x)}$$

$$+ i \tan^{-1} \frac{\tanh \frac{1}{2}\sqrt{3}a}{\tan \frac{1}{2}a};$$

and therefore

$$\omega \log \frac{\sin(\omega a + x)}{\sin \omega a} + \omega^2 \log \frac{\sin(\omega^2 a + x)}{\sin \omega^2 a}$$

$$= -\frac{1}{2} \log \frac{\cosh \sqrt{3}a - \cos(a-2x)}{\cosh \sqrt{3}a - \cos a} + \sqrt{3} \tan^{-1} \frac{\tanh \frac{1}{2}\sqrt{3}a}{\tan(\frac{1}{2}a - x)}$$

$$- \sqrt{3} \tan^{-1} \frac{\tanh \frac{1}{2}\sqrt{3}a}{\tan \frac{1}{2}a};$$

and $$\omega^2 \log \frac{\sin(\omega a + x)}{\sin \omega a} + \omega \log \frac{\sin(\omega^2 a + x)}{\sin \omega^2 a}$$

$$= -\frac{1}{2} \log \frac{\cosh \sqrt{3}a - \cos(a-2x)}{\cosh \sqrt{3}a - \cos a}$$

$$- \sqrt{3} \tan^{-1} \frac{\tanh \frac{1}{2}\sqrt{3}a}{\tan(\frac{1}{2}a - x)} + \sqrt{3} \tan^{-1} \frac{\tanh \frac{1}{2}\sqrt{3}a}{\tan \frac{1}{2}a}.$$

Therefore, finally,—

$$\frac{g}{w^2}(ax - y) = \frac{\pi x}{4K}\left(\cot \frac{\pi a}{4K} + \frac{\sqrt{3} \sinh \frac{\pi\sqrt{3}a}{4K} + \sin \frac{\pi a}{4K}}{\cosh \frac{\pi\sqrt{3}a}{4K} - \cos \frac{\pi a}{4K}}\right)$$

$$+ \frac{\pi x}{K} \Sigma \frac{(-q)^r}{1-(-q)^r}\left(\sin \frac{\pi r a}{2K} + \sin \frac{\pi r a}{4K} \cosh \frac{\pi r \sqrt{3}a}{4K} - \sqrt{3} \cos \frac{\pi r a}{4K} \sinh \frac{\pi r \sqrt{3}a}{4K}\right)$$

$$- \log \frac{\sin \frac{\pi}{4K}(a + x)}{\sin \frac{\pi a}{4K}} + \frac{1}{2} \log \frac{\cosh \frac{\pi\sqrt{3}a}{4K} - \cos \frac{\pi}{4K}(a - 2x)}{\cosh \frac{\pi\sqrt{3}a}{4K} - \cos \frac{\pi a}{4K}}$$

$$- \sqrt{3} \tan^{-1} \frac{\tanh \frac{\pi\sqrt{3}a}{8K}}{\tan \frac{\pi}{4K}(\frac{1}{2}a - x)} + \sqrt{3} \tan^{-1} \frac{\tanh \frac{\pi\sqrt{3}a}{8K}}{\tan \frac{\pi a}{8K}}$$

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$$- \Sigma \frac{4}{r} \frac{(-q)^r}{1-(-q)^r} \sin \frac{\pi r x}{4K}$$

$$\left\{ \sin \frac{\pi r}{4K}(2a + x) + \sin \frac{\pi r}{4K}(a-x) \cosh \frac{\pi r \sqrt{3}a}{4K} - \sqrt{3} \cos \frac{\pi r}{4K}(a-x) \sinh \frac{\pi r \sqrt{3}a}{4K} \right\}$$

And $$\frac{gt}{w}$$

$$= \frac{\pi x}{4K} \left(\cot \frac{\pi a}{4K} + \frac{-\sqrt{3} \sinh \frac{\pi \sqrt{3}a}{4K} + \sin \frac{\pi a}{4K}}{\cosh \frac{\pi \sqrt{3}a}{4K} - \cos \frac{\pi a}{4K}} \right)$$

$$+ \frac{\pi x}{K} \Sigma \frac{(-q)^r}{1-(-q)^r} \left(\sin \frac{\pi r a}{2K} + \sin \frac{\pi r}{4Ka} \cosh \frac{\pi r \sqrt{3}a}{4K} + \sqrt{3} \cos \frac{\pi r a}{4K} \sinh \frac{\pi r \sqrt{3}a}{4K} \right)$$

$$- \log \frac{\sin \frac{\pi}{4K}(a + x)}{\sin \frac{\pi a}{4K}} + \frac{1}{2} \log \frac{\cosh \frac{\pi \sqrt{3}a}{4K} - \cos \frac{\pi}{4K}(a-2x)}{\cosh \frac{\pi \sqrt{3}a}{4K} - \cos \frac{\pi a}{4K}}$$

$$+ \sqrt{3} \tan^{-1} \frac{\tanh \frac{\pi \sqrt{3}a}{8K}}{\tan \frac{\pi}{4K}(\frac{1}{2}a-x)} - \sqrt{3} \tan^{-1} \frac{\tanh \frac{\pi \sqrt{3}a}{8K}}{\tan \frac{\pi a}{8K}}$$

$$- \Sigma \frac{4}{r} \frac{(-q)^r}{1-(-q)^r} \sin \frac{\pi r x}{4K}$$

$$\left\{ \sin \frac{\pi r}{4K}(2a+x) + \sin \frac{\pi r}{4K}(a-x) \cosh \frac{\pi r \sqrt{3}a}{4K} + \sqrt{3} \cos \frac{\pi r}{4K}(a-x) \sinh \frac{\pi r \sqrt{3}a}{4K} \right\}.$$

From these expressions we might calculate Mr. Bashforth's Y and T, given in his Tables IV. and VI., (Bashforth, *Motion of Projectiles*), in terms of x or X, having previously calculated the relation between x or X and p by means of the relation

$$p = a - \frac{1+a^2}{\sqrt[4]{3}\sqrt{(4+a^2)}} \frac{1}{X+A}, \quad = \tan a - \frac{4 \operatorname{cosec} 2a}{1 + \frac{X}{A}},$$

or more symmetrically

$$\frac{1 + ap}{1 + a^2} = \frac{X - A}{X + A}.$$

given at the beginning of the paper (p. 138, Vol. XI.)

The extreme complication of the formulæ, however, render this practically useless; at the same time it is interesting to put on record the complete solution of the motion when the resistance varies as the cube of the velocity.

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The only other case which can be solved completely is when the resistance varies as the velocity, and then it can be shown that with properly chosen oblique axes the equation of the trajectory may be written

$$\frac{gy}{w^2} = \log \frac{x}{c},$$

the co-ordinate axes then being any line parallel to the direction when the velocity is infinite, and the vertical asymptote.

For with the notation of p. 132, vol. XI., "Proceedings of the R. A. Institution," if $n=1$, then

$$P = a - p,$$

and

$$\frac{gx}{w^2} = \int \frac{dp}{(a-p)^2} = \frac{1}{a-p},$$

taking the origin on the vertical asymptote.

Therefore

$$\frac{g}{w^2}(a-p) = \frac{1}{x},$$

and integrating

$$\frac{g}{w^2}(ax - y) = \log x + \text{constant},$$

which, referred to the oblique co-ordinates described above, gives the required result.

The assumptions of $n = 0$, -1 or -2 (*Hypotheses magis Mathematicæ quam Naturales*) will be found to lead to equations more or less reducible. For $n = 2, 4, 5$, &c., the equations are quite irreducible.

The following tables have been calculated by Capt. P. A. MacMahon, R.A. :—

Table I. gives the values of the reduced terminal velocity U deduced from the latest determined values of Mr. Bashforth's K, taken from the "Final Report on Experiments with the Bashforth Chronograph," 1880.

If w be the terminal velocity of a shot of W pounds, d inches in diameter, then the retardation due to the resistance of the air

$$g\left(\frac{v}{w}\right)^3 = \frac{d^2}{W} K \left(\frac{v}{1000}\right)^3$$

or

$$\frac{d^2}{W} w^3 = \frac{g}{K}(1000)^3$$

$$\left(\frac{d^2}{W}\right)^{\frac{1}{3}} w = 1000 \sqrt[3]{\frac{g}{K}}$$

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Denoting this by U and calling it the reduced terminal velocity, then

$$\log U = 3 - \tfrac{1}{3}\log\frac{K}{g}.$$

At velocity v, the retardation due to the resistance of the air is therefore

$$\frac{d^2}{W}g\left(\frac{v}{U}\right)^3$$

and the resistance of the air in pounds, to a shot d inches in diameter, is

$$d^2\left(\frac{v}{U}\right)^3.$$

(This quantity is tabulated in Table II., Appendix to Report VIII., "Final Report," p. 57).

The values of Mr. Bashforth's K are tabulated on the supposition that a cubic foot of air is 534·22 grains ("Final Report," p. 10), which is the case when the barometer stands at 30 inches and the thermometer at 62° F.

K, being supposed to vary as the density of the air, must be increased or diminished by 3 per cent. for every inch of rise and fall of the barometer above or below 30 inches, and must be increased or diminished by $-\frac{1}{2}$ per cent. for every degree Fahrenheit of rise and fall of the thermometer above or below 62° F.

Since U varies inversely as the cube root of K, the corresponding corrections for U must be -1 per cent. and $+\frac{1}{6}$ per cent. respectively.

Table II. gives the value of

$$X = \frac{\mathrm{sn\ x\ dn\ x}}{(1 - \mathrm{cn\ x})^2}$$

in terms of x from $2K$ to 0, proceeding by equal decrements of $\frac{1}{90}K$, (K=1·598142) and is required for the determination of p in terms of x.

Table III. connects the values of a, a, α, $3a + a^3$, γ and $\log\frac{w^2}{g}\frac{\mathrm{x}}{x}$ for values of (a) proceeding by equal decrements of $\frac{1}{90}K$ from $2K$ to $\frac{1}{3}K$.

The distance of the vertical asymptote from the origin,

$$\frac{w^2}{g}\frac{\sqrt[4]{3}\,(4K - \mathrm{a})}{(4 + a^2)^{\frac{1}{6}}\,(4 + 4a^2)^{\frac{1}{3}}},$$

will be found to be a maximum when a = tan 16° 30′.

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TABLE I.

v.	log U.	U.	v.	log U.	U.	v.	log U.	U.
100	2·5819	381·86	710	2·8616	727·11	1320	2·8246	667·73
110	2·5950	393·59	720	2·8636	730·47	1330	2·8250	668·35
120	2·6083	405·82	730	2·8653	733·34	1340	2·8255	669·12
130	2·6199	416·74	740	2·8671	736·38	1350	2·8260	669·89
140	2·6306	427·20	750	2·8689	739·44	1360	2·8265	670·66
150	2·6406	437·12	760	2·8706	742·34	1370	2·8271	671·59
160	2·6500	446·68	770	2·8719	744·50	1380	2·8277	672·52
170	2·6587	455·72	780	2·8730	746·50	1390	2·8284	673·60
180	2·6670	464·52	790	2·8741	748·35	1400	2·8293	675·00
190	2·6748	472·93	800	2·8753	750·42	1410	2·8301	676·24
200	2·6823	481·13	810	2·8764	752·32	1420	2·8309	677·49
210	2·6893	488·99	820	2·8772	753·71	1430	2·8318	678·90
220	2·6960	496·63	830	2·8774	754·05	1440	2·8326	680·15
230	2·7025	504·08	840	2·8775	754·23	1450	2·8336	681·72
240	2·7086	511·25	850	2·8775	754·23	1460	2·8346	683·29
250	2·7145	518·28	860	2·8775	754·23	1470	2·8357	685·02
260	2·7202	525·05	870	2·8775	754·23	1480	2·8368	686·76
270	2·7257	531·74	880	2·8775	754·23	1490	2·8379	688·50
280	2·7309	538·19	890	2·8775	754·23	1500	2·8390	690·24
290	2·7361	544·59	900	2·8775	754·23	1510	2·8402	692·15
300	2·7409	550·76	910	2·8775	754·23	1520	2·8415	694·23
310	2·7456	556·67	920	2·8775	754·23	1530	2·8429	696·47
320	2·7502	562·55	930	2·8775	754·23	1540	2·8442	698·56
330	2·7545	568·15	940	2·8775	754·23	1550	2·8455	700·65
340	2·7586	573·59	950	2·8775	754·23	1560	2·8467	702·59
350	2·7625	578·76	960	2·8775	754·23	1570	2·8480	704·70
360	2·7662	583·67	970	2·8775	754·23	1580	2·8492	776·65
370	2·7697	588·48	980	2·8775	754·23	1590	2·8505	708·77
380	2·7731	593·01	990	2·8775	754·23	1600	2·8516	710·67
390	2·7762	597·26	1000	2·8775	754·23	1610	2·8528	712·53
400	2·7791	601·31	1010	2·8774	754·05	1620	2·8539	714·34
410	2·7819	605·15	1020	2·8770	753·36	1630	2·8551	716·31
420	2·7846	609·02	1030	2·8743	748·69	1640	2·8562	718·13
430	2·7874	612·92	1040	2·8668	735·87	1650	2·8574	720·12
440	2·7901	616·78	1050	2·8556	717·14	1660	2·8586	722·11
450	2·7929	620·73	1060	2·8449	699·69	1670	2·8598	724·11
460	2·7957	624·75	1070	2·8378	688·34	1680	2·8608	725·78
470	2·7986	628·93	1080	2·8328	680·40	1690	2·8618	727·45
480	2·8014	633·01	1090	2·8290	674·47	1700	2·8629	729·29
490	2·8043	637·18	1100	2·8262	670·24	1710	2·8639	730·98
500	2·8072	641·55	1110	2·8243	667·21	1720	2·8650	732·83
510	2·8100	645·66	1120	2·8232	665·52	1730	2·8661	734·69
520	2·8128	649·83	1130	2·8226	664·71	1740	2·8671	736·38
530	2·8156	654·13	1140	2·8226	664·71	1750	2·8682	738·25
540	2·8185	658·36	1150	2·8226	664·71	1760	2·8691	739·78
550	2·8212	662·53	1160	2·8226	664·71	1770	2·8702	741·66
560	2·8238	666·55	1170	2·8226	664·71	1780	2·8712	743·37
570	2·8265	670·66	1180	2·8226	664·71	1790	2·8722	745·08
580	2·8294	675·15	1190	2·8226	664·71	1800	2·8732	746·80
590	2·8323	679·68	1200	2·8226	664·71	1810	2·8741	748·35
600	2·8352	684·23	1210	2·8226	664·71	1820	2·8753	750·42
610	2·8379	685·53	1220	2·8226	664·71	1830	2·8762	751·97
620	2·8406	692·84	1230	2·8228	664·91	1840	2·8772	753·71
630	2·8432	696·95	1240	2·8228	664·91	1850	2·8781	755·22
640	2·8456	700·81	1250	2·8229	665·17	1860	2·8791	757·01
650	2·8481	704·91	1260	2·8231	665·37	1870	2·8803	759·11
660	2·8504	708·54	1270	2·8232	665·52	1880	2·8813	760·86
670	2·8526	712·20	1280	2·8234	665·94	1890	2·8823	762·61
680	2·8549	716·03	1290	2·8237	666·35	1900	2·8832	764·19
690	2·8572	719·84	1300	2·8239	666·70	1910	2·8843	766·13
700	2·8596	723·77	1310	2·8243	667·21	1920	2·8851	767·54

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TABLE I.—(*Continued*).

v.	log U.	U.	*v.*	log U.	U.	*v.*	log U.	U.
1930	2·8859	768·96	2220	2·8943	783·98	2510	2·9251	841·59
1940	2·8867	770·38	2230	2·8943	783·98	2520	2·9259	843·15
1950	2·8875	771·80	2240	2·8945	784·34	2530	2·9267	844·70
1960	2·8882	773·04	2250	2·8947	784·70	2540	2·9275	846·26
1970	2·8888	774·11	2260	2·8950	785·24	2550	2·9281	847·43
1980	2·8892	774·82	2270	2·8952	785·60	2560	2·9286	848·40
1990	2·8897	775·72	2280	2·8957	786·51	2570	2·9289	848·99
2000	2·8901	776·43	2290	2·8963	787·59	2580	2·9292	849·58
2010	2·8905	777·15	2300	2·8971	789·05	2590	2·9292	849·58
2020	2·8909	777·86	2310	2·8983	791·23	2600	2·9294	849·97
2030	2·8911	778·22	2320	2·8996	793·60	2610	2·9294	849·97
2040	2·8913	778·58	2330	2·9010	796·16	2620	2·9294	849·97
2050	2·8915	778·94	2340	2·9024	798·73	2630	2·9297	850·56
2060	2·8918	779·48	2350	2·9037	801·13	2640	2·9297	850·56
2070	2·8920	779·84	2360	2·9050	803·53	2650	2·9297	850·56
2080	2·8920	779·84	2370	2·9065	806·31	2660	2·9299	850·95
2090	2·8922	780·19	2380	2·9079	808·91	2670	2·9299	850·95
2100	2·8922	780·19	2390	2·9094	811·71	2680	2·9299	850·95
2110	2·8924	780·55	2400	2·9109	814·52	2690	2·9303	851·73
2120	2·8926	780·91	2410	2·9123	817·15	2700	2·9303	851·73
2130	2·8926	780·91	2420	2·9138	819·98	2710	2·9303	851·73
2140	2·8928	781·27	2430	2·9152	822·63	2720	2·9306	852·32
2150	2·8930	781·63	2440	2·9168	825·66	2730	2·9306	852·32
2160	2·8932	781·99	2450	2·9181	828·14	2740	2·9306	852·32
2170	2·8934	782·35	2460	2·9193	830·43	2750	2·9306	852·32
2180	2·8934	782·35	2470	2·9206	832·92	2760	2·9306	852·32
2190	2·8937	782·89	2480	2·9219	835·42	2780	2·9306	852·32
2200	2·8939	783·25	2490	2·9230	837·53	2780	2·9306	852·32
2210	2·8941	783·61	2500	2·9240	839·46	2790	2·9306	852·32

TABLE II.

x.	X.	Diff.	x.	X.	Diff.
$2K =$ 3·19628	0·00000	—	2·75236	·11757	·00521
3·17853	·00144	·00144	2·73460	·12286	529
3·16077	·00888	444	2·71685	·12823	537
3·14301	·01333	445	2·69909	·13366	543
3·12526	·01778	445	2·68133	·13919	553
3·10750	·02225	447	$\frac{5}{6}K =$ 2·66357	·14479	560
3·08974	·02672	447	2·64582	·15049	570
3·07199	·03121	449	2·62806	·15628	579
3·05423	·03572	451	2·61030	·16216	588
3·03647	·04025	453	2·59255	·16815	599
3·01871	·04480	455	2·57479	·17425	610
3·00096	·04937	457	2·55703	·18045	620
2·98320	·05398	461	2·53928	·18678	633
2·96544	·05861	463	2·52152	·19323	645
2·94769	·06327	466	2·50376	·19980	657
2·92993	·06797	470	2·48600	·20651	671
2·91217	·07271	474	2·46825	·21336	685
2·89442	·07749	478	2·45049	·22035	699
2·87666	·08232	483	2·43273	·22750	715
2·85890	·08719	487	2·41497	·23480	730
2·84114	·09211	492	$\frac{3}{4}K =$ 2·39721	·24227	747
2·82339	·09708	497	2·37946	·24991	746
2·80563	·10211	503	2·36170	·25774	783
2·78787	·10720	509	2·34394	·26575	801
2·77012	·11236	516	2·32618	·27395	820

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TABLE II.—(*Continued*).

x.	X.	Diff.	x.	X.	Diff.
2·30843	·28236	·00841	1·13616	2·72018	·12410
2·29067	·29099	863	1·11870	2·85225	·13207
2·27292	·29984	885	1·10094	2·99296	·14071
2·25516	·30892	908	1·08318	3·14303	·15007
2·23740	·31824	932	$\frac{2}{3}$ K = 1·06543	3·30325	·16022
2·21964	·32782	958	1·04767	3·47449	·17124
2·20188	·33766	984	1·02991	3·65773	·18324
2·18213	·34778	1012	1·01216	3·85404	·19631
2·16637	·35819	1041	·99440	4·06458	·21054
2·14861	·36889	1070	·97664	4·29084	·22626
$\frac{4}{5}$ K = 2·13086	·37992	1103	·95888	4·53388	·24304
2·11310	·39127	1135	·94113	4·79573	·26185
2·09534	·40296	1169	·92337	5·07809	·28236
2·07758	·41502	1206	·90561	5·38301	·30492
2·06023	·42746	1214	·88786	5·71280	·32979
2·04247	·44029	1283	·87010	6·07004	·35724
2·02471	·45353	1324	·85234	6·45770	·38766
2·00696	·46720	1367	·83459	6·87891	·42124
1·98920	·48132	1412	·81683	7·33763	·45869
1·97144	·49592	1460	$\frac{1}{2}$ K = ·79907	7·83803	·50040
1·95369	·51101	1509	·78131	8·38486	·54683
1·93593	·52662	1561	·76356	8·98385	·59899
1·91817	·54277	1615	·74580	9·64116	·65731
1·90041	·55950	1673	·72804	10·36117	·72301
1·88266	·57682	1732	·71029	11·1613	·7971
1·86490	·59477	1795	·69253	12·0122	·8809
1·84714	·61338	1861	·67477	13·0183	·9761
1·82939	·63269	1931	·65701	14·1028	1·0845
1·81163	·65272	2003	·63926	15·3112	1·2084
1·79347	·67351	2079	·62150	16·1066	1·3504
1·77571	·69511	2160	·60374	18·1755	1·5139
1·75796	·71756	2245	·58599	19·8785	1·7030
1·74020	·74089	2333	·56823	21·8011	1·9226
1·72244	·76516	2427	·55047	23·9798	2·1787
1·70468	·79041	2525	$\frac{1}{3}$ K = ·53271	26·4587	2·4789
1·68693	·81671	2630	·51496	29·2914	2·8327
1·66917	·84411	2740	·49720	32·5433	3·2519
1·65141	·87266	2855	·47944	36·2948	3·7515
1·63366	·90243	2977	·46168	40·6460	4·3512
1·61590	·93350	3107	·44393	45·7213	5·0753
K = 1·59814	·96592	3242	·42617	51·6788	5·9575
1·58039	·99979	3387	·40841	58·7159	7·0371
1·56263	1·03520	3511	·39066	67·0922	8·3763
1·54487	1·07220	3700	·37290	77·1105	10·0183
1·52712	1·11092	3872	·35514	89·2999	12·1594
1·50936	1·15145	4053	·33738	104·155	14·8551
1·49160	1·19391	4246	·31963	122·496	18·341
1·47384	1·23840	4449	·30187	145·410	22·914
1·45608	1·28507	4667	·28411	174·414	29·004
1·43833	1·33404	4897	·26636	211·674	37·260
1·42057	1·38545	5141	·24860	260·350	48·676
1·40281	1·43948	5403	·23084	325·171	64·821
1·38506	1·49632	·05684	·21308	413·426	88·255
1·36730	1·55605	·05972	·19533	536·741	123·315
1·34954	1·61897	·06292	·17757	714·106	177·665
1·33178	1·68527	·06630	·15981	979·979	265·573
1·31403	1·75517	·06990	·14206	1395·30	415·32
1·29627	1·82894	·07377	·12430	2082·79	687·49
1·27851	1·90682	·07788	·10754	3307·32	1224·53
1·26076	1·98914	·08232	·08879	5715·36	2408·04
1·24210	2·07620	·08706	·07103	11162·90	5447·54
1·22524	2·16835	·09215	·05327	26461·86	15298·96
1·20748	2·26598	·09763	·03551	89301·70	62839·84
1·18973	2·36950	·10352	·017757	714373·65	625071·95
1·17197	2·47937	·10987	0·00000	∞	
1·15421	2·59608	·11671			

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TABLE III.

n.	a.	α.	$3a + a^3$.	γ.	$\log \frac{w^2}{g} \frac{x}{x}$.
$2K$=3·196284	0	0°	0	∞	·181750
3·178527	·023374	1° 20′	·0701348	14·258	·181839
3·160770	·046770	2° 41′	·1404126	7·12187	·182106
3·143013	·070230	4° 1′	·2110355	4·73854	·182555
3·125256	·093618	5° 21′	·281674	3·55020	·183171
3·107499	·117344	6° 42′	·353648	2·82767	·183978
3·089742	·141027	8° 2′	·425885	2·34805	·184959
3·071985	·164861	9° 22′	·499064	2·00375	·186122
3·054228	·189016	10° 42′	·573801	1·74277	·187475
3·036471	·213689	12° 2′	·648941	1·54097	·188995
3·018714	·237764	13° 22′	·726732	1·37603	·190726
3·000967	·262391	14° 42′	·805238	1·24187	·192624
2·983200	·287059	16° 1′	·884830	1·13016	·194689
2·965443	·312268	17° 20′	·967252	1·03386	·196963
2·947686	·337809	18° 40′	1·051976	·95059	·199429
2·929929	·363706	19° 59′	1·139230	·87779	·202090
2·912172	·390012	21° 18′	1·229360	·81343	·204949
2·894415	·416709	22° 37′	1·322487	·75615	·208005
2·876658	·443880	23° 56′	1·419097	·70467	·211265
2·858901	·471570	25° 15′	1·519577	·65808	·214735
2·841144	·499813	26° 33′	1·624299	·61585	·218416
2·823387	·528619	27° 52′	1·733568	·57685	·222310
2·805630	·558096	29° 10′	1·848120	·54109	·226430
2·787873	·588256	30° 28′	1·968331	·50804	·230775
2·770116	·619165	31° 46′	2·094859	·47736	·235353
2·752359	·650905	33° 4′	2·228487	·44874	·240174
2·734604	·638518	34° 21′	2·369890	·42196	·245242
2·716815	·717099	35° 39′	2·520050	·39682	·250568
2·699088	·751805	36° 56′	2·680313	·37309	·256174
2·681331	·787464	38° 13′	2·850698	·35079	·262029
2·663574	·824420	39° 30′	3·033590	·32964	·268183
2·645817	·862782	40° 47′	3·230595	·30954	·274651
2·628060	·902574	42° 4′	3·442987	·29044	·281431
2·610303	·943986	43° 21′	3·673163	·27225	·288547
2·592546	·987148	44° 38′	3·923379	·25488	·296014
2·574789	1·03225	45° 55′	4·196673	·23828	·303856
2·557032	1·07951	47° 11′	4·496541	·22239	·312099
2·539275	1·12915	48° 28′	4·827082	·20716	·320769
2·521518	1·18142	49° 45′	5·193261	·19256	·329897
2·503761	1·23665	51° 2′	5·601148	·17854	·339518
2·486004	1·29510	52° 20′	6·058278	·16506	·349677
2·468247	1·35747	53° 37′	6·573868	·15212	·360421
2·450490	1·42399	54° 55′	7·159501	·13967	·371806
2·432733	1·49598	56° 14′	7·835901	·12762	·384004
2·414970	1·57231	57° 33′	8·603977	·11623	·396782
2·397213	1·65574	58° 52′	9·506367	·10519	·410546
2·379456	1·74676	60° 13′	10·56988	·09461	·424309
2·361699	1·846764	61° 31′	11·83876	·08447	·441212
2·243942	1·957571	62° 56′	13·37430	·07477	·458431
2·326184	2·081518	64° 20′	15·26319	·06552	·477187
2·308427	2·221759	65° 46′	17·63236	·05671	·497769
2·290670	2·382624	67° 14′	20·67378	·04837	·520554
2·272913	2·570141	68° 44′	24·68782	·04051	·546041
2·255155	2·793756	70° 18′	30·18676	·03313	·574996
2·237398	3·067241	71° 57′	38·05825	·02628	·608422
2·219641	3·411365	73° 41′	50·04738	·01998	·647982
2·201884	3·878104	75° 32′	69·95978	·01429	·696415
2·182127	4·548164	77° 36′	107·7269	·00928	·758873
2·166370	5·656155	79° 58′	197·9209	·00505	·846911
2·148613	8·120254	82° 59′	559·7990	·00179	·997418
$\frac{1}{2}K$=2·130856	∞	90°	∞	0	∞

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NOTE

ON THE

ARMAMENT OF DRIVERS.

BY

LIEUT. E. A. LAMBART, R.A.

In his interesting note on the Artillery at Maiwand (No. 7, Vol. XI., R. A. Institution Journal), Capt. Fowell, R.A., says:—"I did not see nor hear of any Driver making use of the pistols supplied to Drivers in India." I should like to mention that at the battle of Ahmed Khel, April 19th, 1881, several stragglers of the enemy contrived to penetrate to where the wagons of my Battery (G/4 R.A.) were posted, and were then shot by the wagon Drivers with their pistols, Quarter-Master-Sergeant Birch assisting with his sword.

Only a very few of the enemy got so far to our rear, but the wagon Drivers would have been killed like sheep but for their pistols.

I particularly noticed the conduct of the gun Drivers on the same occasion, when we were closely pressed in front and flank (the enemy were within 40 yards of the guns when we limbered up) and I did not see a single man attempt to draw his pistol; they sat quietly on their horses, and limbered up steadily.

I have written this note because (with the exception of the battle of Maiwand) on no other occasion during the war were Field Artillery attacked in the open at such close quarters; and the facts I have stated seem to throw some doubt on the theory generally accepted in the Regiment, that the arming of Drivers may be attended with dangerous consequences to the Gunners, and tend to distract the attention of the Drivers themselves from their horses in action.[1]

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[1] ["A Sikh, after the retreat of our Cavalry at Chillianwalla, galloped up to the Horse Artillery, cut down and killed the two Drivers on the leading horses of the gun, one after the other, and approached the third, a cool fellow, who, seeing how badly his comrades had come off with their swords, instead of drawing his, stuck to his whip, with which he flogged off his assailant's horse, and thus saved himself!"—*"Cavalry; its History and Tactics," by Capt. L. E. Nolan, 15th Hussars, p. 114.*—H. W. L. H.]

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THE ATTACK OF ARMOUR-CLAD VESSELS BY ARTILLERY.

A Lecture delivered at the R.A. Institution, on 19th October, 1881,

(General Sir COLLINGWOOD DICKSON, V.C., K.C.B., in the Chair),

BY

CAPTAIN C. ORDE BROWNE,

Late Royal Artillery.

Probably most officers will agree to the statement that it is very desirable in the case of a deliberate engagement to know the nature of armour carried by an enemy, and also its thickness, within reasonable limits. It may be well to observe that it ought, in most cases, to be possible to obtain this information, for the number of armour-clad vessels possessed by any power is limited, and such vessels are built sufficiently slowly for their most important features to become widely known before they are afloat, both with regard to outward appearance and construction. It is necessary to state this fact, for on it depends substantially any value that this paper may possess.

When possible, it seems important that a decision should be made as to whether the armoured portion of the ship, containing, what may be termed, the vital parts, should be attacked, or whether it would be better to bring the Battery to bear on to the less protected or unprotected parts. For the sake of distinction, I term the former the "*primary*," and the latter the "*secondary*" attack. Besides, there is also the attack of the horizontal armour on the deck, which is almost a separate question of its own, which, for the sake of convenience, is here put between the primary and the secondary attack. The primary and secondary attacks are best carried out with entirely different kinds of ammunition. It is for this reason that it appears important to adopt and follow one or the other plan of attack thoroughly, instead of firing armour-piercing shells indiscriminately at every armour-clad ship.

Primary Attack.

Whether a ship's armoured portion can be attacked by any given gun with advantage or not, depends on the *nature* and *thickness* of her armour. *Steel* distributes the shock of impact through its mass,

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and hence it has great power in resisting a single blow, but it is liable to succumb to the continued fire even of inferior guns. No better illustration of this could be given than the comparative behaviour of the 22-in. steel and iron plates at Spezia in 1876. The steel crumbled away gradually, even under the fire of 10-in. guns; a fire which proved almost harmless to the 22-in. wrought-iron plates. On the other hand, the steel completely stopped the projectile of the 100-ton gun, which enormously outmatched it. This it did at the expense of the plate, itself shivering into fragments, while the iron allowed this projectile to pass completely through it; both experiments were repeated with the same results. It may be seen, then, that *penetration* through steel is hardly to be looked for, but rather the shattering of it.

A steel-clad ship, from its power to resist a single blow, is admirably suited for running past a small number of guns, however heavy they may be; but, on the other hand, it suffers from the continued fire even of light guns: hence it might depend on the probable duration of an attack whether it was wise to fire at a ship's side armour or only at her unarmoured places. The effect of a shot against steel plates is probably proportional, not to the shot's power of penetration, but to the stored-up work contained in the shot at the moment of impact, which is expressed by $\frac{Wv^2}{2g}$, where W is the shot's weight, v the striking velocity, and g the force of gravity. To take an example:— The 9·45-in. Krupp B.L. gun, firing a shot weighing 348·3 lbs., with a velocity of 1890 feet a second, can, according to Colonel Inglis, penetrate a plate 18·1 ins. thick. The 38-ton gun, 12·5-ins. calibre, firing a shot weighing 812 lbs. can penetrate a plate 17·9 ins. thick only. That is to say of the two, the Krupp gun has rather the advantage in penetrating wrought-iron. On the other hand, it may be seen that the 38-ton gun shot has about 12,260 ft. tons stored-up work, whereas the Krupp gun has only 8,630 ft. tons work. Consequently, while the latter gun would be equal, or slightly superior to the former if fired against iron, two rounds of the former would probably produce nearly the same effect as three rounds of the latter against steel plates. It appears reasonable to suppose that the cracking of the steel represents the stored-up work in the shot as fully as the sheering effected in the wrought iron; although, in so curious a mechanical problem as the cracking and breaking up of steel which goes on for some minutes after the moment of impact, it is unsafe to dogmatize. One conclusion arrived at by the Sub-Committee on Plates and Projectiles is that it is necessary to attack steel-faced armour with steel projectiles; the fact, I believe, being that chilled iron under the sudden resistance experienced breaks up before the conditions favourable to its success are established.

Steel-faced armour, that is armour composed of a wrought-iron foundation plate and steel-face plate, comes under the heading of steel in a modified form: not that a plate composed of a compromise between steel and wrought-iron would answer, for the object is to have a hard surface and tough back. Compound armour, however, so far

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11-in. plate of Brown's after being struck by the following projectiles:—Three 9-in. chilled shot from a 12-ton gun; one 9-in. steel with chilled point; and one 12·5-in. steel shot from a 38-ton gun. The latter projectile has only penetrated to a depth of from two to three inches in the steel—flattening out and breaking up, but still making a hole through the plate at the point of impact. The metal in the shot may be rather soft, but the shield has borne its blow of 11,820 ft. tons admirably. Three of the 9-in. shot contain about the same total quantity of work. I fear, however, that it would be difficult to make a diagram such as would enable you to compare the effect of the one heavy and three light projectiles.

Wrought Iron.

Wrought-iron yields locally at the point of impact only. It is universally admitted that for direct fire a sharp pointed projectile is best. This forces in its sharp point, which experiences comparatively slight resistance at first, and soon gets deep enough to cause the plate to begin to yield at the back, just opposite to the shot's point, in a star or cross-shaped tear, which is opened; the corners bending back as the shot gets deeper until, at length, the projectile forces its way through, mainly by tearing the iron in lines, whose lengths are directly proportional to the calibre of the gun. It is this action that appears to support the use of the first power of D, rather the square in the formula used for so many years in the Department of the Director of Artillery. However, what is mainly to the point here is the fact that the shot shears or punches a comparatively clean hole, leaving the surrounding portion of the armour and fastenings almost uninjured. I have here two photographs, taken almost at hap-hazard, being duplicates from the R.M. Academy which were not required for Cadets. These sufficiently exhibit the well-known behaviour of wrought-iron under continued fire—one in the case of direct and the other oblique fire. In the latter, the effect of the blow is more distributed than in the former. For all practical purposes, however, it may be considered that unless a projectile passes through *wrought-iron* sufficiently far to cause injury by langrage, it effects nothing. Even a projectile passing bodily through, in the form of dead metal, may produce but a very limited amount of damage; the armour of the ship being left in good condition, except that it has a clean hole through it, and even that may be plugged up by the base of the projectile. In the case of Palliser or steel shells fired under ordinary conditions, a certain thickness of iron will probably cause the charge of the projectile of almost any gun, even the heaviest, to explode at an early stage of penetration, so that the flash does not get through the armour. So long as armour-clad ships were able to keep all *fire* out, they enjoyed a measure of security altogether beyond that belonging to wooden ships, even supposing them to be penetrated through and through.

The possible introduction of steel projectiles, which stand up to their work and retain their shape sufficiently well to allow them to

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carry a bursting charge entirely through the armour, seriously threatens this advantage. You see before you a 9-in. Whitworth steel shell which was fired by the Sub-Committee on Plates and Projectiles. This shell has, as far as I can ascertain, passed twice through a solid iron plate 12 ins. thick. It is not of the best proportion of calibre to weight, nor has it the best shaped head, yet it is capable of carrying a guncotton charge unexploded through 12 ins. of iron, for this was actually effected by one supplied with it. It will be seen that this danger can hardly be said to threaten *steel* armour seriously, for a shot must enormously overmatch a steel plate to get through it, as we have seen in the case of the Spezia trials.

The *increased power* that has been obtained in *new type guns* still further favours the attack of iron by penetration. Let us take an actual experiment showing what might be effected by *new type guns* firing *steel shell* with *guncotton* charges. At Meppen, in August, 1879, a Krupp gun, 9·45 in. calibre, weighing 17·7 tons, was fired at a target consisting of 20 ins. of wrought iron in two thicknesses, namely, 12 ins. and 8 ins., sandwiched with about 3 ins. of wood between the plates. The projectiles passed through the target and went 3500 yds. up the range before grazing. When recovered, they scarcely showed signs of having been fired. They could undoubtedly have carried guncotton charges through the plates. It is a serious reflection that a new type 18-ton gun may be able to drive a projectile carrying fire into the strongest parts of any English ship afloat, except the citadel of the *Inflexible*.

Where wrought-iron is concerned, then, it is practically a question either of "*perforation*" or else failing to damage at all; consequently, it is specially important to know what is the limit of a gun's power at any range. Very complete diagrams showing this have been drawn up by Colonel Inglis and Colonel Maitland, which will be found in the "Report on Plates and Projectiles." Colonel Maitland has, I believe, recently completed a diagram, from which additional information such as the diminution of velocity of any shot, on any increase of range can be taken directly. As officers are not likely to want to decide these questions with guns in action, which they are handling for the first time, these diagrams might be used to furnish them complete information as to their guns before coming into action. I think, however, it may be well to have also a rough rule for fixing the limit of a gun's power against wrought-iron, which can be carried in the head: I may, therefore, point out a very simple one, namely, *one calibre thickness of armour for every thousand feet velocity*. I believe this was noticed by different officers in the case of the Armstrong gun trials. It is no matter of chance, but admits of mathematical proof, if two suppositions are made, neither of which is monstrous. Sometimes both are true, and how far they are wrong may always be known and allowance made. I would point out, however, that the simple application of the rule is never very far from the truth. Herewith is a table (*see* p. 49) showing the thickness of plate penetrated by projectiles of nearly all the best known heavy guns at velocities of 1000 ft., 1500 ft., and also at the muzzle velocity of each gun as taken from Col. Inglis'

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diagram, and also as obtained by this simple rule. It may be seen that in the maximum penetration column, in two cases the result is absolutely correct, in twelve instances the error of the rule is only the fraction of an inch, and in seven cases it exceeds an inch. In the two other columns the differences are rather larger. I give the mathematical proof of the rule herewith,[1] by which it may be seen that the two assumptions required are (1) that the formula formerly used in the Director of Artillery's Department is correct when the resistance of the plate is supposed to increase with the square of its thickness; (2) that the ratio of the weight to the cube diameter of the projectile is about ·4. The first of these is most nearly correct when the velocity of the projectile is about 2000 ft., and the latter in the projectiles of new type guns is close to the truth. Whether these conditions are approximately true or not, would probably be known; for an officer would know generally whether his gun fired light or heavy projectiles in proportion to its calibre, and whether its velocity was high or low: he ought, therefore, without trouble, to get better results than those on the table. To take an example, however,—where nothing is known and allowed for—say that an officer has 9-in. guns, and supposes a enemy to be 1000 yds. off (failing actual knowledge); an old type gun's initial velocity might be guessed at 1500 ft., and a really new type one at 2000 ft., the velocity falling about 100 ft. for every 500 yds. range. Guessing the 9-in. gun as having 1500 ft. initial velocity, and consequently 1300 ft. at 1000 yds., the limit to possible penetration would be 1·3 calibres, or something under 12 ins. This is one of the worst examples; the 9-in. shot being light for its calibre, and the diagram shows well under 11 ins. Even this, however, is a better result than a guess is likely to yield.

Take a new type gun, however,—such as the 43-ton gun—say at 1500 yds., guessing 2000 ft. as initial velocity, and taking 300 off for the three 500 yds. in the range, we get a velocity of 1700 ft., and limit of penetration of 1·7 calibres, or something under 20½ ins. Colonel Inglis gives 20·9 ins.; surely for a quick estimate, made without data, this is close. However, this subject may be dismissed by observing

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[1] The equation formerly employed in the Director of Artillery's Department may be written—

$$t = \sqrt{\frac{W v^2}{2g \times 2\pi R \times c}}$$

where t = thickness of plate perforated, v = striking velocity, g the force of gravity, $2R$ or D = the diameter of hole or of shot making it, and c = a certain constant. Assuming that the weight of every projectile bears a *constant* relation to the calibre that is ($W = c' D^3$), and collecting all the constants together under the letter K, by which we may express all the constant part of the expression, we have—

$$t = \sqrt{K \frac{D^3 v^2}{D}}$$

$$= \sqrt{K D^2 v^2}$$

$$= \sqrt{K}\, D\, V$$

Experience shows that the constant part, $\sqrt{K} = \frac{1}{1000}$; in other words, that the penetration in inches is equal to the calibre × the number of thousand feet velocity.

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that officers should be provided with diagrams, and from these obtain an accurate estimate of the powers of their guns at any likely range. Failing diagrams, a table of velocities, with the rule of one calibre for each thousand feet, gives a fair idea; and even if the velocity has to be guessed, the rule gives a much better estimate than a direct guess at the thickness would be likely to yield.

Supposing that the enemy is known to carry iron armour at all over the limit which is calculated for the most favourable circumstances, it is useless to fire at it, and the secondary attack might then be adopted. Before dealing with that, however, may be noticed the attack of the deck.

Attack of Decks.

This, when practicable, is probably the most formidable of all, but may be attempted with guns incapable of piercing the side armour. Batteries in positions of high command may generally prefer to fire at the deck. This attack is formidable in proportion to the descending angle, both with regard to the possibility of penetration and the mischief that may be done when penetration is achieved.

The four 100-ton guns which are going out to Malta and Gibraltar will be mounted with about 90 ft. command above the sea. Unquestionably these guns would terribly injure any ship they struck on the deck. Probably they would employ common shells. The more common case to consider would be that of much smaller pieces. It was concluded at Shoeburyness, in 1870, that 9-in. guns at 8° would not penetrate single inch decks at 100 yds. At 15°, as it appears from recent experiments, they would destroy double that thickness of deck plating. The position of the ship affects this question: a broadside view gives but little opportunity. On the other hand, some vessels have special protection when lying head on. The armour bulkhead of the *Shannon* is an instance; she might be much better struck from astern. In some cases, I believe, vessels attack by following each other on an elliptical path, firing in succession from the nearest point to the fort. In such a case some guns might be devoted to fire at the receding vessels. On the occasion of her capture, the Huascar kept her stern away from the enemy systematically.

Secondary Attack.

Protected vessels have latterly come in in notable instances where the armour is almost confined to the water-line, as in the Shannon class; or to the machinery, &c. (vital parts), as in the Italia and Lepanto. Even citadel ships, like the Inflexible, Duilio, Dandolo, Ajax, Agamemnon, Majestic, and Colossus, have unarmoured ends, which may be attacked by ordinary projectiles. In fact armour-piercing projectiles would be likely to do little injury to these parts, for projectiles which depend on violent impact for firing their powder most likely would not explode at all. The Director of Naval Ordnance, in writing on the Inflexible about 1877, said:—"The projectiles that would be fired at the Inflexible

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would certainly be armour-piercing, either chilled iron or steel; and such shell would not burst in passing through the thin iron sides of the ship, as they require the resistance of armour to ignite the bursting charge." The Committee wrote:—"The most effective armament to bring against the Inflexible's ends alone, would undoubtedly be one of numerous shell guns." At the present time, perhaps, we should hardly assume that every foreign Naval or other Artillery Officer would prefer an inefficient mode of attack to an efficient one. Possibly, however, few officers present even to-day would think of attacking an armour-clad in her weak parts with *shrapnel shells* and *sensitive fuzes*. Yet the Shannon trials at Shoeburyness, in 1875-76, indicated that this was often the most effectual kind of fire. The profile resembling the Shannon at Shoeburyness had 1-in. of iron and steel in different portions. Common shells with Pettman fuzes sometimes acted well, but more frequently broke into a few fragments, the powder only firing after the fracture, and so burning without much effect. Even with the Laboratory sensitive or direct action fuzes this was liable to happen. The behaviour of shrapnel, which break up into a multitude of fragments and bullets, is much less dependent on the bursting charge than that of common shell. One shrapnel in these trials dismounted a gun and destroyed the entire detachment, and the effect of these shells was generally remarkably good. Probably common shell for incendiary effect, and shrapnel to sweep the batteries, both having sensitive fuzes, would be the proper projectiles to fire. It is important to bear in mind that common shell have been found equal to the penetration of armour half their calibre thick, that is, 10-in. shells, 5 inches, a 16-in. shell 8 inches.

The portions of ships below the water-line may appear to some to present a vulnerable spot to aim at; and doubtless this is a possibility to be kept in view, but it is at present scarcely feasible to strike the sides of English, or most foreign, ships below the water-line. The *conning tower* in another important mark for attack. It may be remembered that Admiral Grau was killed in the conning tower of the *Huascar*, which was repeatedly struck and eventually destroyed by the guns of her adversaries. The *funnel* may appear to be a tempting mark for light guns, but little can be done by striking it above deck, as the following consideration may show:—

The boilers are placed low down in the hull, and the funnels must be measured from the fire grates. Suppose the total length of funnel to be 50 ft., and that it is cut down to 30 ft. The diminished power of generating steam will be to the original power in the proportion of $\sqrt{30}$ to $\sqrt{50}$, that is, 5·5 to 7·1. The ratio of the speed is, I believe, proportional to the cube root of the generating power, that is, as $\sqrt[3]{5\cdot5}$ to $\sqrt[3]{7\cdot1}$, or about 1·763 to 1·920. In other words, the vessel would only lose 1 knot in 12 by such an injury—though inconvenience might doubtless be felt from the escape of smoke on deck.

Models of Ships of War.

These models of hulls are intended to show the general plan and the

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disposition of guns and armour of a few typical ships of war, to enable officers to understand their general construction, and form their own judgment as to how Coast Batteries should deal with the classes of vessels they represent. The projectiles and fuzes recommended are those indicated by experiments, in some cases not yet introduced into the service.

The models are all made to the same scale, viz., 16-ft. to the inch.

They are painted in accordance with the vessels they represent, except that on one-half, sections of the armour and the face of it also are painted. Wrought-iron is coloured dark blue, and steel plum-coloured, or light blueish colour (*vide* FACE of Inflexible turret). They are weighted with lead to float nearly at the depth of the water-line.

The *Glatton* and *Inflexible* are made from Admiralty drawings, and have been corrected in the Admiralty, and are fairly accurate. The *Admiral Duperré* and *Polyphemus* are made chiefly from drawings in "KING'S WAR SHIPS," and "THE ENGINEER," and do not claim to be accurate in all respects.

GLATTON, (BRITISH).

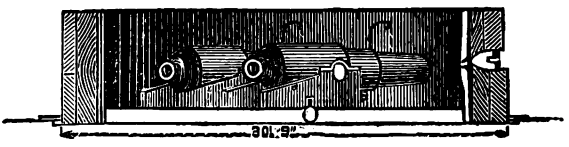
Coast defence; breastwork, single turret type; length between perpendiculars 245 ft., extreme breadth 54 ft., displacement 4912 tons.

The principal Artillery features are,—

All-round-fire with two 25-ton guns, combined with *complete protection* by *heavy* armour. She is fitted to engage with an enemy of great power, because her all-round fire enables her to place herself obliquely to the enemy's guns. When built, it appeared as if she was unlikely to suffer from the effect of the heaviest guns then extant.

At Portland, in 1872, her turret was fired at by the 25-ton gun of the Hotspur. One round struck the centre of the turret near the ports; the plates were forced back 5½ ins., and some distortion caused (*vide* Figs. 2 and 3). The 2nd round struck the junction of the turret

FIG. 2.



with the glacis-plate of the deck (*vide* Fig. 4). The object being to try the effect of wedging the turret and so preventing its working, the shots were directed at the most likely places to cause this; the 14-in. plates being selected rather than the 12-in. plates, which would have allowed the shot to pass through with less shock to the ship. Perforation was not effected, and the turret was in no way prevented from working freely.

The introduction of new type guns, firing projectiles of comparatively small calibres with high velocity, *in no way favours the operation of distorting a turret,* but rather the reverse, for the power to contort

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depends on the resistance offered, and this decreases with the calibre of the projectile.

Fig. 3.

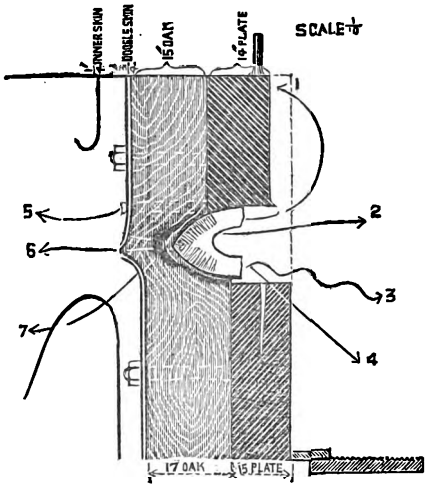
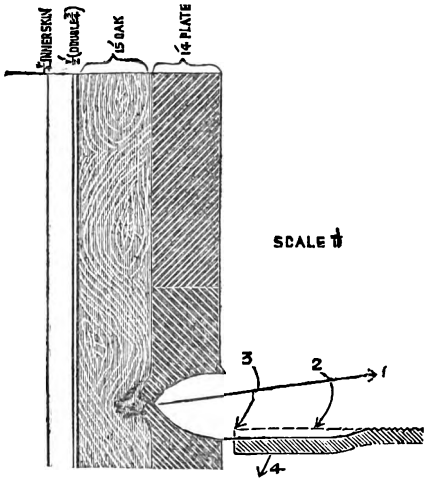


Fig. 4.



The introduction of new type guns, and also of steel shells which remain intact after penetration, will, however, seriously detract from the invulnerability of this vessel to *penetration*. A new type 9-in. gun might undoubtedly perforate her sides and turret at close quarters *striking directly*. Steel shells charged with guncotton and delay-action fuzes would be the most formidable projectiles to attack her with. Taking her altogether, with her powers of all-round fire and *complete armour*, she would still probably bear heavy Artillery fire very well. Against two antagonists, the fact of her possessing only a *single turret* is a

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disadvantage. The Captain and staff are very secure in the conning-tower, immediately aft of the turret. This ship is erroneously described as having no ram in some foreign works on ships of war.

The coast defence vessels of Great Britain are the

Glatton.	Gorgon.	Wyvern.	Magdala.
Hotspur.	Hecate.	Scorpion.	Abyssinia.
Rupert.	Cyclops.	Viper.	Cerberus.
Prince Albert.	Hydra.	Vixen.	

Our seagoing turret ships *Dreadnought, Thunderer, &c.*, resemble the *Glatton* generally as to armour.

The French first class coast defenders of the *Tonnerre* class closely correspond to these.

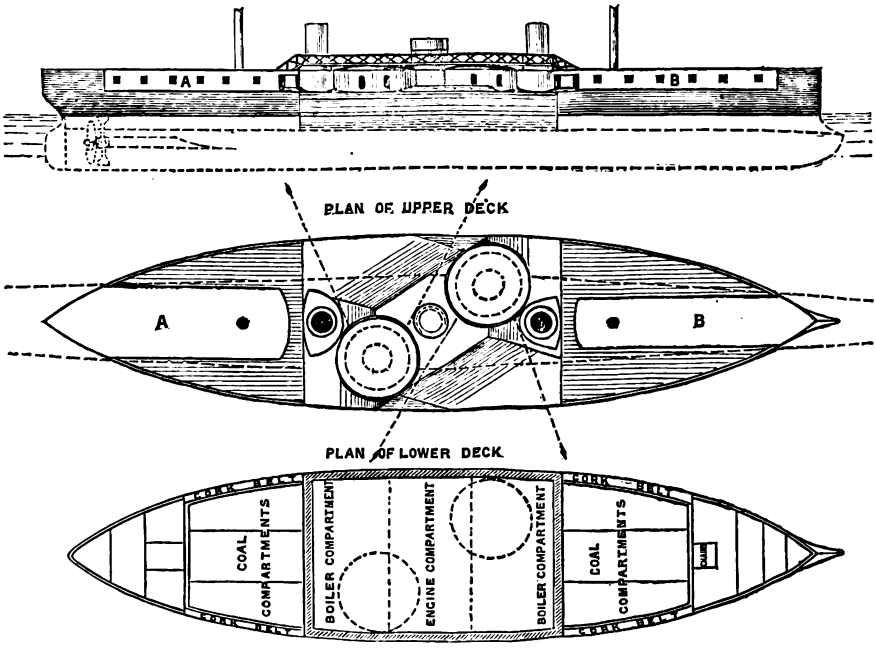
The Russian Navy has many vessels of this type including the "*Great Peter.*"

Inflexible, (British).

The largest iron-clad at present afloat; length between perpendiculars 320 ft., extreme breadth 75 ft., displacement 11,406 tons. (The Italian ships *Italia* and *Lepanto* will be larger, viz., 13,480 tons).

Type, *Citadel. Diagonal turret* type of sea-going ship (*vide* Elevation and Plans, Fig. 5). The *Agamemnon, Ajax, Colossus, and Majestic*

Fig. 5.



(English ships) are being built on the same plan. The Italian ships *Duilio* and *Dandolo* are also on the same principle.

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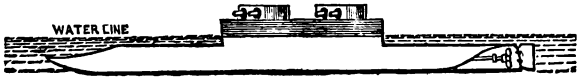
The model is made to pull assunder (masts and rigging being left out) so as to enable the vulnerable unarmoured portions to be removed, leaving the armoured citadel, with its turrets and its submerged projecting ends, covered with horizontal armour (*vide* Fig. below).



Portion of H.M.S. Inflexible protected by vertical or horizontal armour.

Supposing this part of the vessel only to be left sufficiently perfect to keep out water and cause displacement, thus giving floating power, the rest of the ship would be merely dead weight; and Sir E. Reed argued that in such a condition this ship, as well as the *Duilio* and *Dandolo*, would be liable to capsize. Practically, considering the construction of the superstructure with its cork, &c., (*vide* model section), this is out of the question. It could only be effected by many days of continued firing. The citadel is very heavily armoured (*vide* model,—24 ins. in thickest parts. Turrets have 16 ins., (17 ins. at ports), the outer plate of 9 ins. being steel-faced (light blue or plum colour on model section.)

It would be useless to attack the heavily armoured parts of this ship with anything of much less power of penetration than the 80-ton gun. Practically, the 80-ton gun would severely injure her only by repeated blows. She would also be able to resist plunging fire very well. With smaller guns all ships of this class might be attacked in the unarmoured parts by common shells and sensitive fuzes, and shrapnel with special sensitive[1] percussion fuzes. Lighter guns also might disturb the Captain and staff of the vessel posted in the corners of the iron plate cross in the conning tower[2] near the foremast (on model).

As to her own fire; the diagonal position of turrets is intended to to enable the citadel to be shortened, and thus to effect a saving in armour and weight. It is also meant to give fire with four guns (80 tons) fore and aft. This has not yet been actually attempted. The turret guns have fired hitherto only up to about 15° of this line, and thus pointed are only directed on two adversaries 30° asunder.

The *Duilio*, which so strongly resembles the Inflexible, has steel armour which might gradually be destroyed by comparatively light guns, but would probably stop a single projectile of any gun afloat. She has no deck structure containing cabins like that of the Inflexible, but her funnels and casings which are outside her citadel interfere with all-round-fire. The vessel is narrower than the Inflexible, and the turrets are therefore necessarily constructed with their centres in a line making a smaller angle with the keel than is the case with the Inflexible. Although, as already said, there is no prospect of causing a vessel of this class to capsize by destroying her unarmoured ends; these might be so far injured as to cause serious inconvenience, and they form a natural object of attack for any but the very heaviest guns.

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[1] Not the fuze formerly termed "sensitive."

[2] The cross plate is surrounded by very thin walls and roof in the actual ship.

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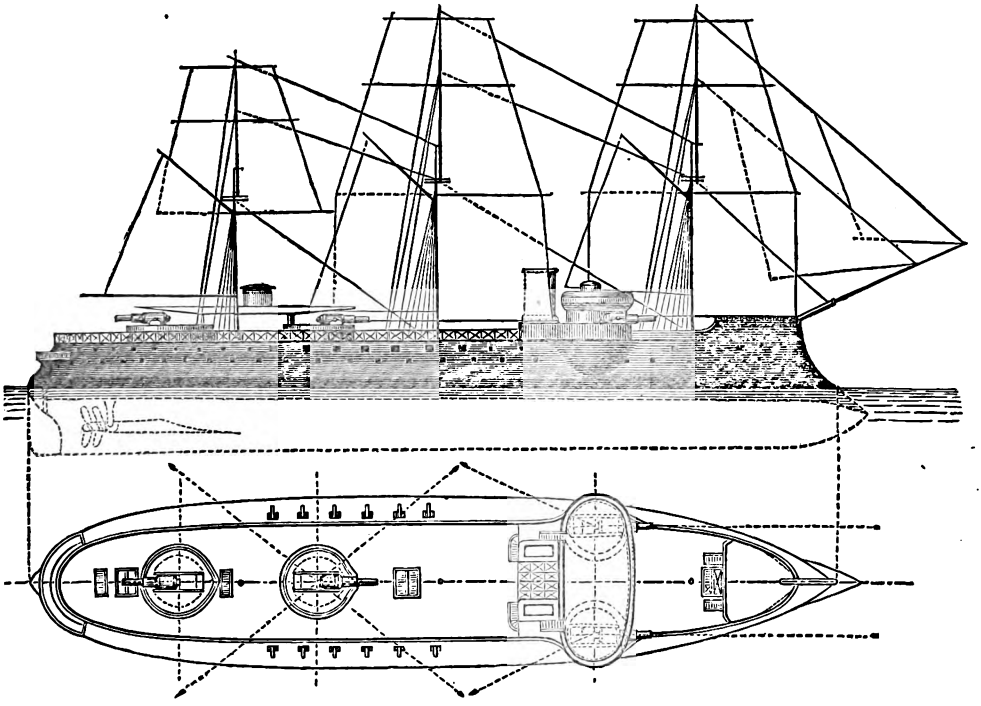
The Admiral Duperré.

Length on water line 319 feet 10 ins., extreme breadth 66 ft. 11 ins., displacement 10,322 tons (French); building; *special barbette type*, copied more or less in other French ships—the *Duguesclin, Triumphante, Victorieuse, La Gallisonière, &c.*, (*vide* King's War Ships)—is armoured only along the water-line and on the towers, being a "protected ship" rather than an "armour-clad." The guns (46 ton) revolve on turntables, one in each barbette tower. There are also 14 broadside 5½-in., guns unprotected (*vide* Elevation and Plans, Fig. 6).

Fig. 6.



The principal Artillery features are the great command of her guns (27½ ft. above the water-line), and her power of all-round-fire; though, it is to be observed, that is perhaps less complete than in turret ships. She fires two guns directly ahead—probably only one directly astern. She can hardly fire her *four* heavy guns in any direction. She will have, however, great power of offence if she carries new type broadside guns.

Her defence is very imperfect; she is open to attack from common shells (of all calibres) with sensitive fuzes, and even larger machine guns, in all unarmoured parts. Shrapnel with special sensitive fuzes might also be used against the broadside guns, and shrapnel with time fuzes or special percussion fuzes, and bullets from machine guns might

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be directed on the men in the barbette towers, as well as common shell with percussion fuzes.

The English ship *The Collingwood* is being built on the barbette system, though with much more regard to protection than is exhibited in this ship.

The Polyphemus.

Length on water-line 240 ft., extreme breadth 40 ft., displacement 2640 tons. Ram and torpedo ship. She carries no heavy guns, her weapons being the torpedoes which she discharges from her bow and on each side amidships, machine guns, and her ram which simply consists of her steel bow torpedo tube strengthened by ribs (*vide model*), consequently she must not be expected to discharge torpedoes from her bow after once ramming.

She is protected by steel scales and steel plating specially made by Sir J. Whitworth & Co. The sides of the vessel are made of double ½-in. ship-building steel of about 26 tons per inch tenacity. The entire "turtle back" to 5 ft. below the water-line is covered with a Whitworth steel inch plate (45 tons tenacity). From 2½ ft. below the water-line the turtle back is further protected by Whitworth steel scales, till the tangent to the curved back comes down to 20° with the horizontal. These scales are each about 10 ins. square and 1 in. thick, held on by one screw in the centre and one at each corner, holding down the corners of 4 plates, so that each plate has one screw in the centre and a quarter of a screw at each corner, making 2 screws for each plate throughout. The steel for the scales has a tenacity of 65 tons. The scales will resist the direct blow of any machine gun easily, and may perhaps prove suited to resist a very *oblique* blow, even from heavy projectiles, to which only they are exposed in action.

This vessel has special peculiarities which are not Artillery matters, such as the power to drop heavy weights carried along her keel, (in all 240 tons) so as to make her float higher, and recover herself if a compartment fills with water, &c.

The best method of attack might be to fire armour-piercing projectiles as directly as possible, common shell, charged with guncotton, and percussion fuzes might also be tried. Her top structure might be destroyed by the projectiles of almost any guns. Common shells filled with guncotton and with percussion fuzes might probably be the best.

The engagements of the *Huascar*—more particulary that one which ended in her capture—may seem to deserve special notice in this paper. This, however, is a matter on which I should hope to hear something from Naval Officers in discussion, and I would only put before you drawings of the Huascar (*vide* Plate, Figs. 1, 2, and 3, showing the places where she was struck) which have been kindly contributed by Lieut. Montgomery, R.N., of H.M.S. Shannon, adding a very few remarks.

Officers unacquainted with the Huascar, from the general resemblance she bears to own turret vessels, might take her to be much stronger than she really is. She has only 5½ ins. of iron on her turrets, 4½ ins.

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on her sides, and 3 ins. on her conning tower; and she carried two 10-in. guns, two 40-prs. and 1 field gun. On the occasion of her capture she maintained a very gallant fight for 1¾ hours against two vessels, enormously outmatching her, protected by 10 ins. of armour. She endeavoured to keep between them, to keep her weak parts out of fire and to ram, which was defeated by the advantage her adversary (The Cochrane) possessed in having twin screws. Finally, when her staff and half her crew were disabled, and she had resisted one attempt to board, she surrendered. It seems ungracious to point out any flaw in so noble a defence, but the fact cannot be allowed to pass that her guns failed in their part, for neither in her encounter with the English vessels Shah and Amethyst, nor on the occasion of her capture, can she ever be said to have hit any ship to any purpose, though at times at close quarters.

The two models before us, the Inflexible and Admiral Duperré, may serve to remind us of certain points of contrast between our own ships and those of France. We have, either afloat or well advanced in building, 11 first class turret sea-going ships, and 15 coast defenders, in which is embodied the principle of carrying a very few very heavy guns behind thick armour—the turret principle enabling the guns to engage on either side. The French ships have generally more pieces, but of lighter weight. The average number of heavy guns in our first class turret ships is 5·1, and in our first class broad-side ships 11·1, while in the French first class ships it is 15·3. The total weight of metal, (in ordnance) carried (which may, perhaps, be best shown by the number of tons displacement per ton of gun) is as follows:—English turret, first class, 56·1; broadside, 43·5. French, first class, 39·5; second class, 52·3. The advantage of the all-round fire of the turrets may enable the English ship to bring a great weight of Artillery into action perhaps; but the question is, whether the greater number of guns carried by French ships may not be an advantage which must not be overlooked. So long as the medium guns carried in broad-sides could not pierce our armour, the question was less serious than it may shortly become if medium new type guns are carried capable of piercing nearly everything we have afloat. No doubt we can hardly for a moment compare the *Admiral Duperré* and the *Inflexible*. The 80-ton guns of the latter ought to penetrate the thickest part of the Admiral Duperré's armour, striking fairly, up to over 2000 yds. range; while the 46-ton guns of the Admiral Duperré could not pierce the citadel of the Inflexible. On the other hand, the English ship could in many positions only engage with two guns. The Inflexible is the bigger vessel by over 1000 tons. The Admiral Duperré could, perhaps, compare better with the Dreadnought, 564 tons bigger than herself whose armour her heavy guns could readily pierce; but much better with the Colossus class, because her light guns would find work on the unarmoured parts, while her men would work in the barbette towers and behind the thin unarmoured iron sides of the ship with comparative impunity, owing to the small number of her adversary's guns.

It is not here denied that heavy guns have a special power of their own, in comparison with the same weight of lighter ordnance. Colonel

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Inglis has suggested one case, which deserves notice, when a heavy gun might effect more than many light guns, namely, against chilled iron armour. The French, Germans, Russians, Danes, Dutch, Spanish, and Portuguese have forts of chilled iron on their coasts. This material resists a good deal of heavy fire without suffering severely. It is employed on the presumption that at sea it is difficult for ships to plant many shot near the same spot. It appears likely that the blow of a projectile from an 80 or 100-ton gun might wreck a great portion of a chilled iron parapet entirely. However, this is a question of ships and forts, which certainly concerns our Naval Officers but hardly the English Artillery, as it is difficult to imagine a case in which they would attack the Coast Batteries of European Powers, and we have no chilled armour on our own coasts.

With the object of inviting discussion, it may be well to draw one or two conclusions. It is therefore suggested, 1st, that at present we need *medium new type guns* introduced as far as possible into the armaments of our ships and forts. Against *steel*, such guns are, in their measure, available for gradual destruction, and very heavy guns can only deal with steel in the same way, though much more rapidly, that is to say, they crack it to pieces, but do not actually pass on into the ship. Iron must be *punched*, and how well this may be done by a new type gun is seen from the fact that we found an 18-ton new type gun beating an old type one of 38 tons; 2nd, that the secondary attack of weaker parts of armour-clad vessels by common or even shrapnel shells deserves more attention than it has received. Lastly, there is a disposition to take advantage of a few very heavy guns by exposing detachments and confining armour to the vital parts, which form the natural object of attack of such pieces.[1]

At the conclusion of the Lecture the Chairman invited Naval and Artillery officers, and others present, to take part in the discussion of the subject.

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[1] Since reading this paper I have learnt from Naval Officers that the presence of submarine mines may compel ships to anchor in order to engage forts. It appears to me, therefore, that high-angle fire deserves more consideration than it has received. At Meppen, an 11-in. howitzer struck a target, representing roughly the deck of the Inflexible, five times out of ten rounds, at a range of over 7000 yds.

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TABLE SHOWING HOW FAR THE RESULTS GIVEN BY THE RULE OF THUMB AGREE WITH THOSE OF COLONEL INGLIS' DIAGRAM.

NATURE OF GUN.	Calibre.	$\frac{W}{D^3}$.	At Maximum or Muzzle Velocity.				Penetration at 1500 ft. Velocity.			Penetration at 1000 ft. Velocity.		
			Velocity.	Penetration. By Rule of Thumb.	Penetration. By Diagram.	Difference, Rule of Thumb — Diagram.	By Rule of Thumb.	By Diagram.	Difference.	By Rule of Thumb.	By Diagram.	Difference.
100-ton Armstrong B. L.	17·72	·40	1500	26·6	25·3	+1·3	26·6	25·3	+1·3	17·7	16·1	+1·6
" " M. L.	17·72	·36	1735	30·7	28·1	+2·6	26·6	24·0	+2·6	17·7	15·3	+2·4
71-ton Krupp B. L.	15·75	·44	1653	26·2	26·5	−0·3	23·6	23·8	−0·2	15·8	15·2	+0·6
80-ton M. L.	16·0	·42	1613	25·8	25·2	+0·6	24·0	23·3	+0·7	16·0	14·6	+1·4
51-ton Krupp B. L.	13·98	·42	1650	23·1	23·0	+0·1	21·0	20·7	+0·3	14·0	13·1	+0·9
46-ton French B. L.	13·38	·39	1640	21·9	20·9	+1·0	20·1	19·0	+1·1	13·4	—	—
38-ton M. L.	12·5	·42	1475	18·4	17·9	+0·5	—	—	—	12·5	11·7	+0·8
38-ton Krupp B. L.	12·01	·43	1650	19·8	19·7	+0·1	18·0	17·8	+0·2	12·0	11·3	+0·7
43-ton B. L.	12·0	·42	2005	24·1	23·9	+0·2	18·0	17·5	+0·5	12·0	11·1	+0·9
25-ton M. L.	11·0	·41	1410	15·5	15·0	+0·5	—	—	—	11·0	10·3	+0·7
26-ton B. L.	10·4	·41	2080	21·6	21·6	+0·0	15·6	15·1	+0·5	10·4	—	—
25-ton Armstrong B. L.	10·0	·40	2012	20·1	20·0	+0·1	15·0	14·5	+0·5	10·0	—	—
18-ton M. L.	10·0	·42	1515	15·2	14·7	+0·5	15·0	14·5	+0·5	10·0	9·3	+0·7
17·7-ton Krupp B. L.	9·45	·42	1890	17·9	18·1	−0·2	14·2	14·0	+0·2	9·5	8·9	+0·6
18-ton B. L.	9·2	·41	2000	18·7	18·7	0·0	13·8	13·4	+0·4	9·2	8·4	+0·8
18-ton Armstrong B. L.	9·0	·34	2250	20·3	19·0	+1·3	13·5	12·1	+1·4	9·0	—	—
12-ton M. L.	9·0	·35	1540	13·9	12·4	+1·5	13·5	12·1	+1·4	9·0	7·7	+1·3
11½-ton B. L.	8·0	·36	2040	16·3	14·9	+1·4	12·0	10·8	+1·2	8·0	6·9	+1·1
3·9-ton Krupp B. L.	5·86	·55	1664	9·7	11·5	−1·8	8·8	10·2	−1·4	5·9	6·6	−0·7
5-ton French B. L.	6·28	·40	1738	10·9	10·7	+0·2	9·4	9·1	+0·3	6·3	5·7	+0·6
4-ton Armstrong B. L.	6·0	·37	1960	11·8	11·2	+0·6	9·0	8·3	+0·7	6·0	5·3	+0·7

The Rule of Thumb gives the best results when V = 2000 feet about, and $\frac{W}{D^3}$ = ·41 about.

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COLONEL MAITLAND.—I wish to say a few words on a very small point. A table is exhibited, attributing certain velocities to the guns named therein. Some of these velocities are erroneous, and I think the table should not go forth unchallenged. Thus, the Armstrong M. L. 100-ton gun has a velocity of 1550 f. s. instead of 1735 f. s., and the 38-ton M. L. of the service has a velocity of 1540 f. s. instead of 1475 f. s. Lower down the table, stands an 18-ton Armstrong B. L. gun with a very high velocity. This, I believe, has no existence, except, perhaps, on paper. I merely mention these points that it may not be supposed that the table represents actual results.

SIR GEOFFREY HORNBY.—It requires a considerable amount of presumption in anybody to address you after the very able Lecture we have heard, but having been invited by the Chairman, as one of the Naval Officers present, to join in the discussion I should like to make one or two remarks from a Naval point of view upon the question of forts and ships. I think it must be manifest to you all that ships have one great advantage, viz., that they need never approach the forts unless they please, while the forts must remain to be fired at. No Naval Commander, I presume, would attempt to attack a fort without he knew what the armour was that he wsa covered with, and he would not attack a fort unless he had a very good chance indeed of seriously damaging the enemy, whilst he would not receive more injury than he had made up his mind to receive. Therefore the question between an iron armoured ship and an armoured fort comes back very much to what it was between a wooden ship and a wooden fort. We have the examples of Lord Nelson at Copenhagen, Lord Exmouth at Algiers, Sir Robert Stofford at Acre, and Admiral Porter at Fort Fisher; the question they all asked themselves was this, can we bring so many guns to bear upon each gun in that fort as to silence it? They thought they could do so, and they attempted it and were successful. The question arises now, is there any chance of an ironclad doing that in the case of an armoured fort? On the first blush one would say No. Ships are very much longer than they were, and they carry very much fewer guns in proportion to their length, whereas with a fort we have an unlimited space, and therefore the means of having an unlimited number of guns. But if you look at the thing more practically, I think you will find that the positions are rather reversed. In the case of the old sailing ship you required a certain amount of space between each ship; you had to approach under sail, and of course you had to think of how to get away if it became too hot for you, and therefore you required a certain amount of space in which to get under weigh. With iron and steel armoured vessels the position is reversed, you may put your ships as close together as you please. The distance within which vessels can now be anchored of one another may be measured by feet where formerly it had to be measured by fathoms. Wooden ships could not be placed much less than two cables apart, so as to enable one ship to weigh clear of the other. Now you have no hesitation in anchoring within a cable length of another ship, because you can anchor ships by both ends with perfect ease, and with the assistance of the screws you can keep them exactly in that position, even if the anchors do not hold. Now take the case of any forts that we know. Though they cover a considerable amout of space the guns are few, the reason of the limited number I suppose is because the expense of making the fort is so very large. As an instance to show the advantage that iron ships have as against iron targets, I will refer to Malta. Probably you are aware that the defence of Malta consists practically in an attempt to defend the line of coast from Pembroke Camp to Marsa Scirocco on the south-east side of the Island. On the south-west and the south there are high cliffs, which would prevent any enemy from landing, and though the north-west is not so protected, yet it is cut off from the remaining part

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of the Island by a position which soldiers say is an extremely strong one, therefore you have only to defend the Island in that limited space to which I have referred. That being the state of things, a Naval man looking at it would say "If I had to attack this how would I do it?" Of course he would attack at one end of the line, and Pembroke Fort seems to be one of the most vulnerable points of attack. I put the question to Colonel Murray, who was there, whether he did not think that with five ships, the ships would have considerably the advantage over the forts, that is, that one ship might mask the fire of any single gun that would be brought to bear upon the ships, and the other four ships might bring something like four guns against any one gun of the fort. As far as our experience goes it really looks as if ships would be able to bring against forts a greater number of guns than the forts would be able to bring against them, and so be able perhaps to damage the forts very materially. One thing is certain, that if the ships get the worst of it, they can always go away, if the forts get the worst of it they cannot go away. We are anxious to see our coal depôts in all parts of the world defended, and in making provision for their defence, we have to look forward to guns two or three times more powerful than those of the present day. Captain Browne has shown us that the new gun is nearly twice as powerful as what he calls the old gun, that is to say, the gun of 10 years ago, and we must look forward to a similar increase in the power of guns in the future. There is one other matter upon which I will make a remark; Captain Browne speaks rather contemptuously of the Polyphemus as an Artillery ship. I admit that as an Artillery ship the Polyphemus is contemptible, because she carries no guns but a saluting gun; but that ship, as it seems to me, is the embryo of a class which may be more formidable as against Coast Defence Batteries than any other, because she is practically very nearly a submerged ship. At present, as the Lecturer pointed out, there is a question whether the Inflexible, when she was deprived of her two ends, would capsize or not; we know that if any ordinary armour-clad ship is submerged to a certain extent she must turn bottom upwards, because the upper part is heavier than the other. In the Polyphemus that is not quite the case, she is laden with a very heavy keel, so that she would be kept upright till the water nearly flowed over her. We see that in the Whitehead torpedo we have a submerged body which keeps itself afloat though entirely submerged. That ship suggests the idea that we may very soon build a ship that shall be totally submerged when she goes into action. If so, what is it she will show for you to fire at? Nothing but a small tower upon which you may pile armour of almost any thickness. That one turret of, we will say, 26 ft. in diameter, is all that the fort will have to fire at. Supposing you had six vessels of that kind anchored within 600 yards of one another and playing upon the one or two guns of the fort, I think the fort would perhaps have a very bad time of it. With regard to another point, I think the conflicting views upon the construction of the Inflexible are not difficult to reconcile in this way. Naval men who look at the Inflexible as a vessel to attack would say we must fire at what, from our point of view, is the vital part, that is the guns, and the centre part which covers her boilers, and so forth; to do that we must attack her with very heavy guns. The Committee on the other hand were very much impressed with what Mr. Reed said about the risk of upsetting the vessel—not when she was deprived of those two ends which the lecturer lifted off, because Mr. Reed did not say that—I think what he said was that if those two ends got very much injured, so that they got full of water, you would find that with the water washing about in them, the ship would have a tendency to roll over. As regards the secondary attack of a fort upon the Inflexible, she would probably bring the fort to bear at an angle of 45° to the line of the keel; in that case the fort would not be able to injure the after end of the ship, the after end would be so far protected that the stability of the ship would not be likely to be affected. I think the Captain of the ship would

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always know when her stability was becoming affected at all, and when that state of things arrived, it would be a simple matter of slipping cable and steaming away. Then a remark was made as to the Shannon, which I think I might say a word in explanation of. The Lecturer spoke of the Shannon having a very strong protection forward, which she has, and he also spoke of the Shannon target as having been pierced by shrapnel shell, and he pointed out the great loss that would be inflicted upon the crew if that happened in actual warfare, but that target was a target of the side, which was merely a thin piece of iron, and it was found that in firing through that, the damage done to the crews of the opposite guns would be frightful; and one thing is clear, that if ever the ship went into action, with her guns manned on both sides, the men on the side opposite to the side attacked must all be brought to the side attacked, or put down below. On the further side of the target the destruction was frightful. But the Shannon is a very peculiar vessel, a vessel that has a shield athwartships to protect two 18-ton guns, which fire directly forward in the line of the keel, the other guns are placed directly broadside, they are light guns, and they stand under no armour at all, they are simply thin iron, and the effect of shrapnel on that iron is certainly bad for the crew.

MAJOR PORTER.—I should like to ask the Lecturer one or two questions about the ships of France. We have been led to believe by the Lecturer that the French are trusting to a larger number of guns and of smaller weight compared with ours. I would ask how that is compatible with the French "*Carnet*," in which it is stated that four sea going ships, each carrying four guns of 75 tons each, the Admiral Baudin, the Formidable, and two others, and four coast defenders similarly armed are under preparation. The policy advocated by the Lecturer appeared to be that we should provide ourselves with medium guns. That also appears to be the view of a great many people in England. I cannot understand how the carrying out of that policy can provide England with guns capable of coping with those of France.

COLONEL NUGENT.—I should like to say a word or two with reference to some of the observations which have fallen from the Naval Officer on the right of the Chairman (Sir G. Hornby). It may be well perhaps if I state in general terms what is an Engineer's view with regard to some points which he raised. First of all, I think I understood him to say that in old times the guns of wooden ships bore the same relation to the guns of wooden forts (I presume he meant the forts of that day) as do the guns of iron ships to the guns of iron forts in the present day. As he spoke it occurred to me that in a ship of the Duke of Wellington class there was a gun for every 7 feet run of ship, whereas in a ship of the Inflexible class there is only one gun for every 80 feet run. That is a great difference. Next with regard to the comparative offensive power of iron forts, double-tiered; roughly speaking, in iron forts there is a gun for every 20 feet, so that while the power of guns has increased, the number of guns per fort has not, at all events as a necessary consequence, decreased. With regard to the expense of providing guns in such forts, in the Spithead Forts (which are a most expensive type of iron fort) every gun cost £18,000 (I am speaking in round numbers and entirely from memory—I did not expect to take part in the discussion), whereas in the Inflexible every gun cost £200,000. I do not propose to say anything upon the question whether ships should anchor at a cable's length apart, or whether they should attack in motion or from anchor, that is a Naval question which I leave Naval Officers to deal with, though Engineer Officers have a strong opinion upon that point. I will only trouble the Meeting a few moments further with some remarks about the defensive strength of Malta. I happen to know Malta, and,

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speaking again from an Engineer's point of view, I must say that I cannot at all agree with the conclusion of the Naval Officer on the Chairman's right. No doubt he did rightly say, *i.e.*, "in carrying out one mode of attack, that the way to attack Malta would be to attack Sliema." I grant that, but I do not grant that Sliema is easily attacked, but conceiving it to be attacked, and conceiving it to be taken, you would be little better off than you were before, you would still have to come to the main front. If Sliema is silenced Malta is not taken—you must enter by the front door. The defences of Malta are so arranged that they gain in strength, both offensive and defensive, as you approach the vital part. It would take much longer than you would like to go further into the defence of Malta, but I do not think that in an attack the advantage would be with the ships.

Captain Orde Browne.—With regard to Colonel Maitland's remark that some of the velocities given in the table were erroneous, I ought to explain at once that my object was not to show in the table what each gun was capable of doing, but only to show how far a certain rough way of dealing with the question approached what I may call the official solution of it. I have calculated a great number of these velocities myself, but instead of giving those I took Colonel Inglis' which are in some sense official, because if anybody found fault with them, I wanted Colonel Inglis to be responsible for them and not me. These results which I have given are taken from Colonel Inglis' figures. Seriously speaking however, I noticed myself that in the case of the 38-ton gun, the velocity was low; but I would point out that table has not been prepared in any way for the purpose of showing the actual power of the guns, but only to show how near you could get a certain effect from a certain velocity. With regard to Sir Geoffrey Hornby's valuable remarks on ships, he spoke, I think, of the conflicting views with regard to the Inflexible. I do not think there was anything conflicting in those views. What the Director of Naval Ordnance said was that you might expect that any enemy would attack the Inflexible with armour-piercing projectiles, and he supposed that such projectiles would not injure the unarmoured ends much. His presumption was that, generally speaking, the enemy would say, "This is an armour-clad vessel," and they would get armour-piercing projectiles and attack with them; he was possibly right, but it argues ignorance on an enemys part, for the Committee said that the most dangerous attack she could experience would be a large armament of shell guns. I have called attention to the Admiral Duperré especially, because in the Committee's Report you will see it was said that it was very improbable that any ship would ever be afloat that had a large number of shell guns, because they spoke of the great surface that would have to be covered with armour, which necessarily could not be of any very great thickness, and they supposed that the guns would have to be placed a considerable height above the water, and therefore they said it was extremely improbable that the Inflexible could ever meet a vessel with a large number of guns that would fire shell. But it is a question whether the French have not met that by presuming that it would not be worth the while of a ship with a few heavy guns to fire at detachments, and therefore running the risk of exposing their men and guns, dispensing to a certain extent with armour, and being enabled thereby to carry a larger number of guns. With regard to the Shannon target I did not mean to imply that the bulk-head shield that the Shannon carried was what was fired at at Shoeburyness. I know that it was the single inch iron on her sides. In answer to Major Porter's question whether I have any information as to the vessels that are being built by France I must say that I know very little about them. It is quite possible that the French may be copying us in having a few very heavy guns, and I do not say that a few very heavy guns may not be very valuable, but the question to consider is, now that armour is being to a certain extent dispensed

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with, whether those heavy guns should not be supplemented by medium new type guns, because advantage seems to be taken of the small number of our guns. Now that the new type gun is able to effect so much more than formerly, it seems more important to consider the possibility of its introduction. Colonel Nugent did not say anything for me to reply to, but Sir Geoffrey Hornby pointed out the importance of having forts made to meet the growing power of guns. I mentioned that almost all the coast forts abroad were made of chilled armour. This is a section of a fort near Antwerp (*pointing to a drawing on the wall*) made of chilled iron. That stands a certain number of rounds wonderfully well, but eventually it breaks to pieces, as shown. We want more experience of firing against chilled armour in this country; but as Colonel Inglis in his paper, printed in our Proceedings, pointed out, chilled armour is not calculated to meet the growing power of guns. You cannot add to chilled armour very well in front. Chilled armour is very effective in resisting the attack of a gun of a certain weight, but suppose you bring guns against it two or three times that weight, then it is of very little value. The forts we have are made on the sandwich principle, they are made with the view of being continually added to. Take the Portsmouth Forts, you can add thicknesses of armour to them almost *ad infinitum*. Therefore if the great object is to meet the growing power of guns, England has exactly the sort of coast fortification that does meet it. With reference once more to French ships, I wish I knew more about them than I do. I have got my information about them from "*King's War Ships;*" Major Porter appears to have had access to some confidential document which I have not seen.

CHAIRMAN.—I wish before we separate to move a vote of thanks to Captain Orde Browne for his very able and interesting Lecture. He has given us a great deal of useful information upon the subject, and I hope he will have an opportunity before long of imparting to us some more, for the introduction of more powerful guns will, in my opinion, in the course of a very few years, necessitate an entire change in the armour we are using, both in material and construction. I believe no one is so convinced of that as the Lecturer himself. The Lecturer has shown us very ably both the power of Artillery against iron, and the sustaining power of iron against ordnance at the present time, but I believe there is coming a time when we shall have to change our forts, and very likely the plating of our ships will have to undergo a change. No doubt England with its wealth will be better able to stand that operation than any Foreign Power. I have seen the list Major Porter alluded to, and I think Admiral Symonds in his letter to the *Times* referred to those ships and the new type guns they have got, but I believe that none of the new ships are yet constructed, they are only in embryo, and I should think we should be quite equal to meeting them before those guns are ready to be placed in the ships. That is a question of time and expense. I beg to move a vote of thanks to Capt. Orde Browne for his very able Lecture, and I only regret that amongst the many able Officers present, there were not more to take part in a discussion on the various points dealt with by the Lecturer. We have to thank Sir Geoffrey Hornby for coming here to day and giving us the benefit of his views upon some of the points raised.

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FIG. 1.

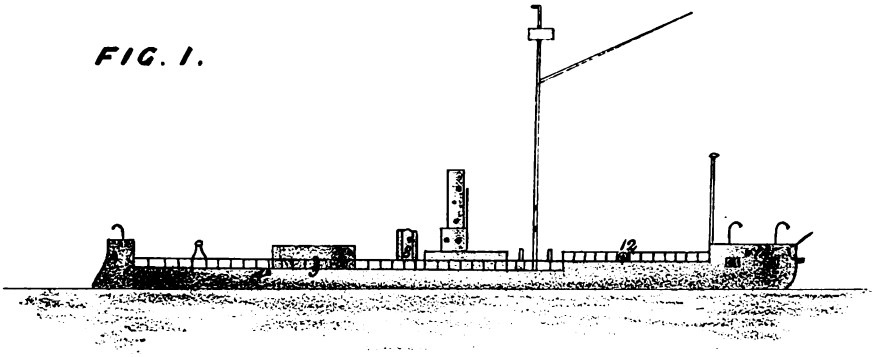


FIG. 2.

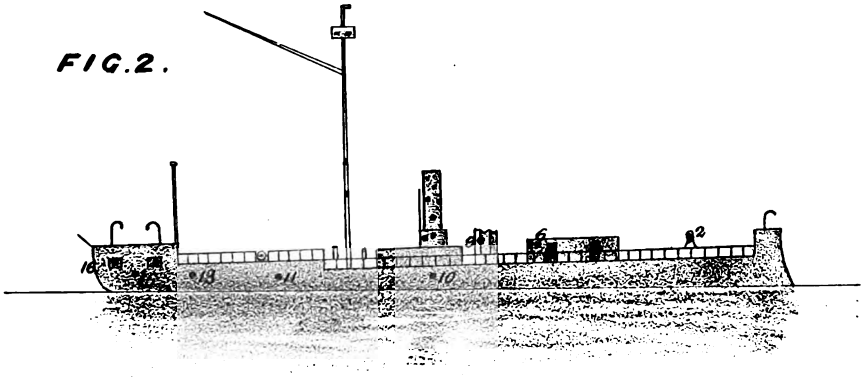
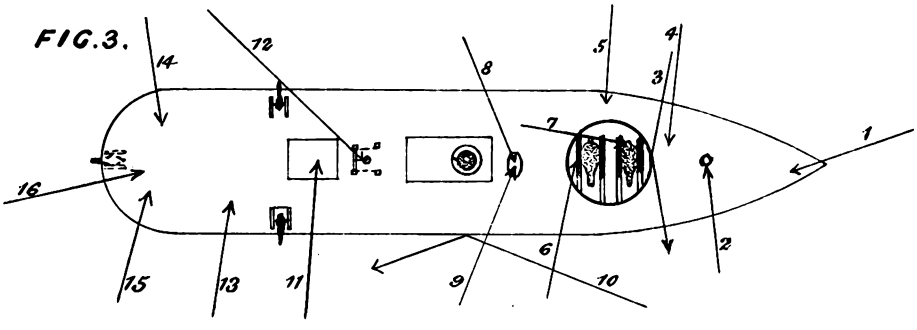


FIG. 3.



INJURIES SUSTAINED BY THE HUASCAR,
8TH OCTOBER, 1879.

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RUSSIAN REMOUNTS.

COMMUNICATED BY

CAPTAIN T. J. ROCH, R.A.

In the "*Bulletin de la Réunion des Officiers*" of the 30th April, 1881, appear some interesting notes on the subject of the horses of the Russian Cavalry and Horse Artillery, and of how they stood the work of the Balkan campaign. M. Harder, an officer in the Russian Hussars, is the original author of the notes in question. He was killed in the passage of the Balkans, and the notes came to an untimely end. Those that there are, however, are full of interest.

The following is briefly the system of remounting followed in Russia:—For every Regiment of Cavalry, for every two Squadrons of the Reserve Cavalry Brigade, and for the horse and Field Artillery of a district, there is a remount officer, who purchases direct from the breeders. The remounts must be passed by the Inspector General of Remounts of the district, who fixes the place of delivery, &c. The remount officer is allowed from 30 to 45 guineas for each of the Guard remounts, and 20 guineas each for those of the Line, out of which he has to forage and shoe his purchases until passsed, and, I presume, leave a margin to cover his losses by rejection, death, &c. I imagine, therefore, that the sum actually received by the breeders for a remount can hardly be called extravagant; while as might be expected from such a system, the assortment is varied. On the one flank of a squadron are to be seen horses of 16-1 or 16-2 hands, which are balanced on the other flank by the humble "*garron*" of 14-2.

Nor is their dissimilarity a mere question of hands and inches. By the side of the light framed horse of the "Don" breed, is to be seen the enormous Russian cart horse that can boast of no pedigree, and which no Russian farmer would ever employ for any purpose requiring a more rapid pace than a walk, but would reserve for the plough or a heavy wagon.

The best horses were the old ones—those, that is to say, which had been seven years or so in the ranks, and it will interest Sir F. Doyle and other "*laudatores temporis acti*," to know that horses such as these are not now to be bought in Russia. If they had a fault (and nothing is perfect) it was that they had too much action. These horses probably came from the "Don," but now-a-days few "Don" horses are to be obtained. From the "Steppes" come some remounts now which resemble the old "Don" type, and some which are more of the non-descript cart horse stamp. As a general rule the Russian Cavalry horse rejoices in the hardest mouth to be found anywhere; M. Harder does not account for this fact. But whatever may have been the breed of horses in the Cavalry and Horse Artillery generally, one thing seems certain, that their condition was bad before they began the campaign, and that a large proportion soon collapsed altogether, after its com-

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mencement; also that the "Hardy Cossack," of whom one hears so much, was the worst of the lot. A few facts which follow show this. The 11th Riga Dragoons were 490 strong in horses before the war, and these were mostly of the "Don" breed, that is to say, of the best breed of all. On the 12th April they had marched 348 miles in 16 marching days, or less than 22 miles a day. But they did not reach Simnitza before the 5th May, so that they only really made an average of something over 14½ miles a day. None the less did all the officers talk of the *forced* marches they had made. The 8th Hussars had in this same march two out of four Squadrons not much the worse in health, but with their feet all to pieces, the other two Squadrons were terribly pulled down; and in the 4th Squadron there were no less than 26 sore backs. M. Harder puts these latter casualties down to the slow pace at which they marched; but, as it is presumed that they all went the same pace, I should be more disposed to blame the Squadron leader. The 8th Cossacks were in the same Brigade. They had nearly 35 per cent. of their horses on the sick list. If they had had to march six or seven days more, M. Harder calculates that half the Regiment would have had to go on foot. No. 9 Cossack Battery (Horse Artillery) was also there. Their horses were in such a state that each Cavalry Regiment had to lend them some to get the guns along. The Battery officers said it was because they had so many requisitioned horses, but No. 4 Cossack Battery had a still greater number unfit to go, although they had nothing but "Don" horses in their teams. This it must be remembered was all before crossing the Danube, that is to say, it was in a friendly country. In Bulgaria they did not fare any better. In each Regiment they could, after a short time, parade with difficulty a single Squadron; and the horses that were not on the sick list were in a dreadful state.

The Turks appear to have been able to annoy them with impunity; their horses showing, so says M. Harder, extraordinary speed when the Russians gave chase, and the "Tcherkess" horses, which the Turks bestrode, are not, as he acknowledges, considered anything wonderful.

In the passage of the Balkans the Artillery were fairly beaten by the post wagons, although the latter had only some mean little Bessarabian horses, while those of the Russian Artillery were great raw-boned skeletons, and it took them sometimes as many as three pairs of extra horses to get up a hill that the clumsy post wagon climbed with only two extra horses besides the ordinary pair. Indeed the postal people said the little Bulgarian horses were infinitely better than the large Russian animals.

The conclusion M. Harder draws is that the sort of horse for military purposes is not an overgrown, 16 hands high, underbred creature, but a short-legged, compact, active beast, in which I need hardly add that our readers will cordially agree with him.

It is satisfactory to find that the Cossack, who is so persistently held up for our admiration, is more or less a delusion. We hear so much of how their "hardy little horses" can beat ours in endurance of hardship and privation that I am glad to be able to think that while taking the utmost possible care of our horses in time of peace, we are not, thereby, ruining them for withstanding the strain of a campaign.

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PRACTICAL ASTRONOMY FOR EXPLORERS.

BY

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(Local Lieut.-Colonel),

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The following remarks have been suggested by Major Gordon's paper in the R. A. I. Proceedings for September, 1881 :—

The sextant is certainly a very portable instrument, but it has many disadvantages. I have always found it awkward to hold in the hand for any length of time and difficult to manage. Taking a double Altitude is a troublesome business, as the artificial horizon must be perfectly free from tremor (those generally sold are much too small), and, when taking a star, it is often difficult to pick out its reflection with certainty when there are others of about the same size in its neighbourhood. The sextant is, moreover, useless if we have to measure a horizontal angle[1] accurately, to find the Meridian Line, to obtain the Longitude without a chronometer, or to take an azimuth observation. For all these reasons I very much prefer the transit theodolite, and strongly recommend explorers to provide themselves with one, if the extra weight is not a serious obstacle. A small instrument—say a 5-inch—is sufficient, and the tripod stand might be made much lighter than those ordinarily used. The theodolite should be a transit one, and should be furnished with a reflector to illuminate the cross-wires at night and a diagonal eye-piece for observing objects at a considerable altitude. The small lamps generally supplied for the reflectors are too small and almost useless, as they only burn for a short time, and get so hot in a few minutes that they cannot be touched. A very much better article is a common bull's-eye lantern which can be held by an assistant so as to throw the light through the lens in the trunnion of the telescope. There should be

[1] The true horizontal angle of two objects of different elevation can be obtained by the sextant, but only by a roundabout process. The angles of elevation of the objects have to be measured, so as to give their zenith distances; and we have then to solve the spherical triangle formed by the two points and the zenith.

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only two spider lines in the field of view—a vertical and a horizontal. The explorer should be provided with some spare spider web (obtained from garden spiders; silk fibre is a tolerably good substitute), and spare glass tubes and plaster of Paris for the different levels. The latter often get broken, but are easily replaced. Any instrument maker would show, in a few minutes, how this is done.

Provided with such a theodolite, a fairly good watch, a set of mathematical tables, and the Nautical Almanack for the year, the traveller would not only have a portable observatory with which he could at any time find the Latitude, Longitude, Meridian Line, and true Local Time, but he would have the means, should he have leisure and feel so inclined, of making an extensive triangulation of the country and obtaining the heights of the hills. The base line might be measured either with a steel tape, or by means of two wooden rods of a given length.

I will say nothing of the adjustments of the transit theodolite, as they are fully described in several books; one of the cheapest is Heather's "Surveying and Astronomical Instruments" in Weale's Series. All observations, as far as practicable, should be repeated in reversed positions of the telescope and horizontal plate, and the mean of the results taken, as certain instrumental errors are thereby eliminated. For instance, in taking an alt-azimuth observation of a star, when the two arcs have been read the plate should be turned round through 180°, the telescope turned over, and the observation repeated. The means of the two sets of readings—one vertical, the other horizontal—will be more likely to be correct than the single readings.

The following are among the most common practical applications of this instrument :—

(1.) Finding the Latitude by a single Meridian Altitude of the Sun or a Star.

(2.) Finding the Latitude by a set of Circum-Meridional Altitudes.

(3.) Finding the Latitude by an Altitude of the Pole Star at any time.

(4.) Finding the Local Time by a single Altitude of the Sun or a Star.

(5.) Finding the Local Time by a transit across the Meridian.

(6.) Finding the Meridian by equal Altitudes of a Star.

(7.) Finding the Meridian by directing the telescope on a Star at the computed time of its transit.

(8.) Finding the Meridian by the greatest elongation of a Circum-Polar Star.

(9.) Finding the Meridian by an alt-azimuth observation of a Star or the Sun.

(10.) Finding the Meridian by transits of High and Low Stars.

(11.) Finding the Longitude by transits of Moon-culminating Stars.

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There are several other useful methods, but I think the above list is long enough.

All Altitudes must, of course, be corrected in the usual way, and the index error (if any) of the vertical arc allowed for.

Problems 1, 2, 3 and 4, have been gone into by Major Gordon; Problem 4 being included in the method of finding the Longitude by a single Altitude. Problem 3 is only applicable to the Northern Hemisphere, and the uncertainty of the refraction near the horizon makes it unreliable near the Equator—say within the Tropics.

A particular case of Problem 1 occurs within the Tropics, which I do not remember to have seen mentioned in any book. The usual rule (quoted by Major Gordon) fails when the Altitude of the Sun has to be measured from the horizon, *below the visible Pole*. For instance, if the Latitude was 10° North, and the Sun's declination 20° North. In this case the corrected Altitude would be 80°, and Z. D. 10°. The Latitude here is the declination *minus* the Zenith Distance.

When a Meridian Line has been accurately ascertained the Latitude may be found with great exactness by clamping the horizontal plate so that the telescope moves in the plane of the prime vertical, and taking the transits of stars across the latter, both east and west, noting the interval of time between the two transits. For this observation the rate of the watch should be known, and the telescope be reversed in its Y's between the two transits. The star chosen should be one which culminates a little south of the zenith in the northern Hemisphere, and *vice versâ*.

The Latitude is found by solving the equation :—

$$\cos \frac{t}{2} \text{ cotan } l. \tan d.$$

Where t is the interval of time between the transits, corrected for rate and reduced to sidereal units, d the Star's declination, and l the Latitude. The hour angle $\frac{t}{2}$ must, of course, be expressed in arc.

Problem 5. This is a very simple operation when the Meridian has been found. In the case of the Sun we have only to take the mean of the times of transit of the east and west edges. At the instant the Sun's centre is on the Meridian it is apparent noon, and by applying the equation of time, corrected for Longitude, we get mean noon. Thus, if the Sun's centre transits at 11·45 a.m., by the watch, and the equation of time is 16 minutes to be *subtracted from* apparent time, the watch will be one minute fast.

With a Star it is different. When a Star is on the Meridian its Right Ascension is the sidereal time of the instant. From this the mean time can be inferred in the usual way.

Problem 6. A Star that describes a sufficiently large arc is selected, the horizontal plate clamped at zero, and the telescope directed on it about two hours before its culmination, so that the star is at the intersection of the wires, and the vertical arc clamped. When the star in its

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descending course has nearly come down to the same altitude as before, the observer releases the upper plate, and watches for it till it again enters the field of view. Using the slow-motion screw of the horizontal plate he keeps the star on the vertical wire, along which it will creep. When it reaches the intersection of the wires the arc on the horizontal plate is read. The vernier is now set at half the plate reading, when the vertical arc will be in the plane of the Meridian.

Problem 7. The watch error must be accurately known. A Star some distance from the zenith, and, if possible, near the Pole, is selected, and the exact *watch* time of its transit computed. At the right time the vertical wire is made to coincide with it, when the telescope will be in the plane of the Meridian.

An improvement on this method is to get the Star on the wire at some fixed time—say three minntes—before the computed time of transit. The horizontal plate is read, released, turned round half the circle, and the telescope turned over. At three minutes after the time of transit the telescope is again directed upon the Star, and the plate read. The mean of the two readings will give the Meridian.

Problem 8. If the telescope is directed on a Star very near the Pole (such as the Pole Star) at the time of its greatest elongation east or west, the Star will appear to move vertically for about half-an-hour. The azimuth of the star in this position is given by the equation

$$\text{Sin } a = \frac{\cos d.}{\cos l.},$$

when a is the azimuth, d the Star's Declination, and l the Latitude. a having been previously calculated we can at once get the Meridian time from the horizontal plate reading. The Pole Star is at its greatest elongation about six hours before and after its transit, the time of which must be computed from the Almanack. If a Star farther from the Pole is used it will be a shorter time on the vertical wire, and its hour angle, or time between culmination and greatest elongation, is given by the equation—

Cosine hour angle = tangent Latitude multiplied by cotangent Star's declination.

The Star's Altitude is given by the equation :—

$$\text{Sine Altitude} = \frac{\text{sine Latitude}}{\text{sine Declination}}.$$

In the case of the Pole Star the Meridian can be obtained at any hour by the formula—

$$\tan A' = \tan A \sin P$$

where A′ is the Star's azimuth at the instant of observation, P its hour angle, and A its azimuth at greatest elongation. This method is very useful when the greatest elongation occurs at an inconvenient hour.

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Problem 9. This problem is a similar one to that by which we find a Star's hour angle by a single altitude. In both cases we have given the three sides of a spherical triangle P Z S, where P is the Pole, Z the Zenith, and S the Star; and from these data we can calculate the angles. For the hour angle we have to find P, and for the azimuth Z. P S is the Star's North-Polar distance, P Z the complement of the Latitude, and Z S the complement of the Star's measured altitude. The angle Z is found from the equation :—

$$\text{Sin}^2 \frac{1}{2} Z = \frac{\sin (s - P Z) \sin (s - Z S)}{\sin P Z \sin Z S}$$

$$\text{Where } s = \frac{P Z + Z S + P S}{2}$$

The Star should be observed at a time when its altitude is rapidly changing. It should be kept upon one of the wires by the slow-motion screw till it reaches the intersection. A comparison of the horizontal plate reading and the calculated azimuth will give the Meridian Line.

Problem 10. Where the Pole Star is not available (as in the Southern Hemisphere) the Meridian may be corrected by transits of stars which culminate near the zenith and near the horizon. If the line is not true the two transits will evidently give different clock errors, the Zenith Star giving a more correct one than the Low Star. The instrument must be shifted a little at a time, and transits of pairs of High and Low Stars taken till they give the same clock error.

Problem 11. This is a very simple though not very accurate way of finding the longitude. For an error of one second in an observed transit may throw the longitude out as much as half a minute in time, or $7\frac{1}{2}$ minutes in arc.

The instrument is set up in the plane of the Meridian, and the *interval of time* noted between the transits of the bright limb of the Moon and of certain Stars, the Right Ascension and Declination of which are nearly the same as that of the Moon at the time. It is not necessary to know either Greenwich or Local Time, but the rate of the watch should be taken into account. The instants of transit are noted, and the interval of time between them is reduced from mean to sidereal time.

In the Nautical Almanack are given, for every day of the year, the sidereal times of transit at Greenwich of the Moon and of certain suitable Stars, called "Moon-culminating" Stars; also the rate of change per hour (at the time of transit) of the Moon's R.A. As the Moon moves rapidly through the Stars from west to east, it is evident that at a station not on the Meridian of Greenwich the interval between the two transits will be different to that at Greenwich; and, the Moon's rate of motion per hour being known, a simple proportion will (if the station is near the Meridian of Greenwich) give the difference of time between the station and Greenwich, and thence the Longitude. If the station is far from the Meridian of Greenwich a correction will have to be made for the change in the rate of change

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of the Moon's R.A. The rate of change at the time of transit is found from the Nautical Almanack by interpolation by second differences, and the mean of the rates of change at Greenwich and at the station is taken as the rate for the whole interval of time between the transits.

An example will best illustrate the method:—

At a station near Kingston, Canada, on the 11th of April, 1881, the transits of the Moon's bright limb and *e* Leonis were observed at 10h. 1m. 55s. p.m., and 9h. 58m. 54s. p.m., respectively. Difference = 3m. 1s., or 3m. 1·5s. in Sidereal time.

		h.	m.	s.
Greenwich Transits	*e* Leonis ...	11	24	16·92
	Moon	11	16	58·10
Difference in Sidereal Time =			7	18·22
Add interval at Kingston =			3	1·50
Total change of Moon's R.A.			10	20·32
			s.	
=			620·32	
By interpolation by second differences the variation of the Moon's R.A. per hour at Kingston was			s. 121·335	
Variation at Upper Transit at Greenwich			120·520	
	2)		241·855	
Mean rate of Variation...			120·927	

$\frac{620{\cdot}32}{120{\cdot}927}$ = 5·1297 hours of Longitude.

= 5h. 7m. 47s. = 76° 57′ 0″ West.

In this case, the Moon was west of the Star at Greenwich and east of it at Kingston, having passed it in the interval.

General Observations.

The order in which observations should be taken on arriving at a fresh station depends on circumstances. In any case the traveller probably has an approximate knowledge of his Latitude and Longitude, so I will suppose him to have let his watch run down. The first Meridian Altitude of a Star he takes will give him his Latitude to a minute of arc, and he can then take an Altitude for hour angle and azimuth, and get his time and Meridian Line. A set of circum-meridional Altitudes can be taken to get the Latitude more exactly.

In Northern Latitudes, when the time is known, the Latitude is easily obtained by Problem 3.

Finding the Meridian by Problem 6 takes too much time. It is best obtained by the greatest elongation of a circum-Polar Star. In the

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Northern Hemisphere there are several stars to choose from, but the Pole Star is the best if it is in position at a suitable hour.

Whenever the Meridian has been accurately laid down the watch may be corrected as often as required by Meridian transits. The Longitude may be obtained with tolerable accuracy by Problem 11, but great care must be taken in observing the transits, as any error in the time between the two transits produces an error 20 to 30 times as great in the Longitude. One advantage of this method is that the calculation is very simple and requires no logarithms. The observer must, however, be acquainted with the method of interpolation by second differences.

If the traveller has a chronometer showing Greenwich Mean Time, he will, of course, use it to find his Longitude. He can form a fair idea of what dependence can be placed on its rate by checking the latter by daily Local Time Observations, (such as Meridian Transits) when resting a few days at any particular place. The chronometer, however, keeps a different rate travelling to what it does when stationary.

For the Meridian Line it is a good plan to choose some well marked distant point as a "referring mark," and then turn the telescope on it with the horizontal plate clamped at Zero before taking the observations for the Meridian. He will thus get the azimuth of the referring mark, and can at any time replace the Meridian mark if it has been removed.

For night work the best Meridian mark is a board with a narrow vertical slit and a lantern placed behind the latter.

The method of Problem 2 gives the Latitude with still greater accuracy if two stars are observed, one north the other south of the Zenith, the mean of the two results being taken.

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NOTE

ON

BASHFORTH'S METHOD OF WORKING TRAJECTORIES,

BY

CAPT. P. A. MACMAHON, R.A.

BEFORE the calculation of a trajectory upon Professor Bashforth's method can be proceeded with, it is necessary to know the mean value of $\frac{K}{g}$ in each arc. Mr. Bashforth in his treatise guesses the corresponding mean velocity, and it is not clear upon what principle he does so.

It is the object of the present note to shew the application for this purpose of the column $\Sigma \frac{K}{g}$ in the tables, in combination with Mr. Niven's degree and velocity table.

Suppose the tangents to the trajectory at the beginning and at the end of the arc to be inclined respectively at angles $\alpha°$, $\beta°$ to the horizon;

v_α the velocity at the beginning of the arc.

From Mr. Niven's table

$$Dv_\beta = Dv_\alpha + \frac{d^2}{w}(\alpha - \beta)$$

and v_β is found at once.

Then, using the new tables (from experiments 1878 - 79)

$$\text{Mean value of } \frac{K}{g} = \frac{5}{v_{\alpha_1} - v_{\beta_1}} \left\{ \Sigma \frac{K v_{\alpha_1}}{g} - \Sigma \frac{K v_{\beta_1}}{g} \right\}$$

where v_{α_1}, v_{β_1} are the nearest velocities to v_α and v_β, which are divisible by 5.

As an instance, take the example given on page 60 of Bashforth's treatise.

Here $\alpha = 5°$, $\beta = 4°$, $v_\alpha = 1335$, $\frac{d^2}{w} = \cdot 56935$

$$\therefore Dv_4 = D_{1335} + (\cdot 56935) \times 1 = 1 \cdot 94485$$

$$\therefore v_4 = 1243 \cdot 3$$

$\therefore v_\beta$, is clearly 1245 and $v_{\alpha_1} = v_\alpha$

$$\therefore \text{Mean value of } \frac{K}{g} = \frac{5}{1335 - 1245} \left\{ \Sigma \frac{K_{1335}}{g} - \Sigma \frac{K_{1245}}{g} \right\}$$

$$= \frac{1}{18} \left\{ 1044 \cdot 27 - 983 \cdot 50 \right\}$$

$$= \frac{1}{18} \left(60 \cdot 77 \right)$$

$$= 3 \cdot 376$$

the correct value with the new tables.

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STRATEGICAL GEOGRAPHY.

A REVIEW:

BY

CAPT. N. L. WALFORD, R.A.

Géographie Stratégique; par le COLONEL G. SIRONI; *traduit de l'italien par* CH. SELMER, *Capitaine au 3e régiment du génie.*

IF we consider war as a game, in which the number of pieces is limited only by the power of the opposing players, while the board is practically limitless, we shall realize how great an advantage will accrue to that one of two adversaries who shall have the most carefully studied the character of his position, and of his intended line of movement. For war is of all games the most complicated, since not only is the original disposition of his pieces left entirely to the choice of the player, but the very board itself, on which the struggle is to be, is divided, not arbitrarily into squares of value only for the piece which stands on any, but into sections which have each a distinct importance to one or both players, according as to whether such a section is held by friendly or hostile forces.

That portion of the art of war which teaches us to study intelligently a country which is likely to become the Theatre of Military Operations has been named by Colonel Sironi "Géographie Stratégique," and on this subject he has written a book of very considerable value, in which he has illustrated his theories and suggestions by many examples drawn from early and recent wars.

The book commences with a series of definitions of the various terms used in the course of the volume, and, though these are probably familiar to most of us, it may be well to show the exact meaning which Colonel Sironi attributes to each.

It may be assumed that in these latter days war is declared by one nation against another, rarely for personal, almost always for political reasons; that the actual cause of war is therefore in general only the last link of a chain of circumstances; and that careful observation, aided by experience, can, within limits, foresee the advent of war.

From this it follows that every State which is within striking distance of a possible enemy must in time of peace prepare an Army, and must on the approach of war determine as to the use to be made of that

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Army. When therefore two nations are on the eve of war, they will, after due consideration of their military power and political aims, select some portion of country which shall serve as an arena for the coming contest; this is called "the theatre of war."

In the majority of cases the position of such a theatre is practically determined beforehand by the character, the strength, and the relative geographical position of the two nations, and such minor changes as may be required by political exigencies, can, as a rule, be allowed for, so that the theatre of war, especially as regards contiguous States, may be considered as fixed, unless their frontiers undergo a complete change.

But after the commencement of hostilities, the movements and action of the opposing troops may extend in any direction over a larger or smaller part of the theatre of war, and that portion which is thus occupied or traversed is distinguished as "the theatre or zone of operations," the latter expression being used more especially to describe the area influenced by one of two forces acting in concert.

An Army in the course of a campaign passes through two distinct phases; (1) it moves by a series of marches into the neighbourhood of its enemy, and (2) having closed with him, it gives battle.

The first phase is governed by the principles of Strategy, the second by those of Tactics; of which the former, in the words of Von Moltke, indicates the best road to the battle, and fixes *where* and *when* it should be fought, while the latter teaches how to use the different Arms during a battle, and *how* it should be fought.

But in addition to these familiar portions of the art of war, there is yet another, which is too frequently passed over in Military History, for the reason probably that it is less brilliant in its action than the others. But it is no less useful and important, for it concerns itself with the order and direction of the various marches, the position of camps and cantonments, of hospitals, of depôts and magazines; it organizes the supply of provisions and ammunition, and arranges for their transport; and further, takes charge of the Intelligence Department of the Army. These duties are included in the term "Logistics," and are the especial charge of the Staff of an Army.

The line, usually the frontier, which divides the opposing armies before the declaration of war is styled the "strategic front," but when hostilities have commenced and the armies have moved, the line which separates them is named the "front of operations."

In every theatre of war there are certain positions, such as mountain passes, fords, cross-roads, railroads, fortresses, &c., the possession of which increases considerably the offensive or defensive power of the occupants. These "strategic points," whether they be valuable for geographical, strategical or political reasons, must be held by an Army in the field, and must be denied to its adversary. But among these points there is generally one, the value of which is pre-eminent; this, which in the majority of campaigns is the capital of the hostile State, is styled the "principal objective," and its capture and occupation are the ultimate objects of all preceding operations.

Minor objectives, such as decisive strategical points, become, at

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various times during a war, the aim of military movements, and serve as it were as stepping stones to the desired end. A force which is about to invade an enemy's country, chooses, usually near the frontier, a line which is strong either by nature or art, and makes of this its "base of operations;" while an army acting on the defensive would use such a line as its "first line of defence."

An Army advancing on its "objective," or retiring to cover the enemy's objective from his attack, moves along several roads more or less parallel; the general direction of these roads gives the "line of operations," and that which is followed by the principal column is held to "direct the march."

Lines of operations, when the campaign is conducted by more than one Army, may be parallel, divergent or convergent.

The first are rare and presuppose two distinct objectives; the second are used only when, as in the case of Napoleon at Dresden in 1813, an Army has to show front to its enemy in various directions; the last are those generally used for the concentration of troops, and a typical example may be found in the Prussian invasion of Bohemia in 1866.

When an invading force advances along parallel or divergent lines of operations, the defender may, by manœuvring between these, succeed in attacking with his concentrated army the isolated portions of the enemy's force. In this case he is said to use "interior lines," and may hope to defeat in detail an enemy who is superior in total strength, but who is thus forced to move on longer "exterior lines." An example of this action may be found in the campaign of Custozza in 1866.

Our space will not permit of a further consideration of Colonel Sironi's maxims relative to lines of operations, nor of his remarks as to the effect on a campaign of the geographical character and position of a base; the latter may indeed be found in every treatise on strategy, and notably in Sir Edward Hamley's "Operations of War."

We may therefore pass on to review that portion of the work which shews the influence exerted by the geographical configuration of various countries on the wars which have taken place in them.

All who have studied military history must have observed that certain portions of the continent of Europe have been from age to age the scene of war, and further that in each of these theatres there are points around which men of different generations have time after time fought for various objects on the same field. The valleys of the Danube, the Rhine, the Po, and the upper Elbe have been for two hundred years the battle grounds of Europe, while Stokach, Soor, Custozza, Rivoli and others, have each given their names to more than one combat fought at different times during that period.

The reason of this partiality of war to certain spots is not far to seek, for its secret lies in the fact that some portions of country are better suited than others to military operations, and that war, being impossible on a large scale in mountainous regions, is forced by its nature into the river-basins of Europe.

An Army which endeavours to move on the shortest line to its ob-

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jective, may be turned from its course by two kinds of obstacles, viz. :—

(*a.*) Natural obstacles, such as the sea, rivers,[1] mountains, marshes, or forests.

(*b.*) Artificial obstacles, such as fortresses; and it may further be induced to prefer one of any two possible lines, by,—

(*a.*) Natural facilities, such as valleys, rivers,[2] &c., or,

(*b.*) Artificial facilities, as roads, railroads, bridges, or the advantages of supply to be derived from cultivated lands and the population of towns.

Natural obstacles and facilities differ from those which are artificial, inasmuch as they are permanent, and being liable to no change, either during a campaign, or even during centuries, are always a fixed factor in military operations. Again, artificial obstacles, such as fortresses, depend for their value entirely upon the natural characteristics of their position, since, if their site be not chosen with a due regard to these, they may be entirely neglected by the enemy, and will so become a source of weakness instead of strength, since their garrison will be lost to the defender's Army.

We may further notice that roads and railroads, with rare exceptions, follow the lines of natural facilities, and may therefore be regarded merely as improvements which men have made on the natural highways; while towns and highly cultivated districts lie always, for obvious reasons, along the banks or in the basins of streams and rivers. From these facts we may argue that all artificial difficulties and facilities are dependent upon the natural character of the ground, and that by considering the effect of the latter on war, we shall practically include in our remarks the influence exerted by the former.

The principal natural phenomena that influence war are, as we have said before, the sea, rivers, mountains, valleys, marshes, lakes and forests, and to these may be added large open plains.

(1.) The sea limits the theatre of war; it may cover a flank, or to a maritime power afford a secure base, and may even, supposing that an invader has absolute command of it, form practically part of his line of operations, while as a frontier line it serves as a good protection to a State, provided the points on the coast which are suitable for the landing of an invader are few and easy of defence. To the above it may be added that the possession of the sea gives to an invading Army the power of shifting its base, a power which is sure to be useful and may be of vital importance.

For example, the British Army, or a great part of it, having been forced to embark at Corunna, was in a few weeks at Lisbon, again ready to commence operations; and at the latter end of the Peninsular

[1] When perpendicular to a line of operations.
[2] When in prolongation of a line of operations.

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war, when the advance of the Army had unduly lengthened its lines of communication, Wellington was able to repair this defect by shifting his base to the ports of Northern Spain.

(2.) Lakes and marshes are impracticable to large bodies of troops, but they are seldom of any great extent, and can be easily turned; in the case, however, where they form part of a line of defence, they limit the extent of front which is liable to attack, or may cover the flanks from the enemy. If, as in East Prussia, they form a general characteristic of the country, they further tend to diminish the number of roads available to an Army, and to make of each road a defile. But with the exception of the large Alpine lakes, their action is as a rule tactical rather than strategical.

(3.) Extensive plains in the widest sense are generally deserts and unsuited to military operations; but open country, accessible in every part, and broken only by slight undulations, is a most favourable theatre of war; the nature of such districts is, however, so complex, and so much depends upon their roads, their fortresses, and other details, that it is impossible to speak of them generally, since each has from these a distinct character of its own.

The smaller plains which were in old days used almost exclusively as battle fields, are not as a rule suited to the size of modern armies, or to the character of modern tactics, which no longer admits of the slow and formal deployment customary in the days when the limit of fire was far within the limit of vision.

(4.) Forests serve principally as a screen to conceal the movements of troops; for forest fighting, though costly, is seldom decisive; while a forest, like the night, prevents the possibility of undivided command, or of combined movements, and is therefore unsuited to the action of a large or well-disciplined force.

There remain now to be considered, rivers, mountains, and valleys, and these Colonel Sironi holds to be the truly important items in the relation of Geography to Strategy.

(5.) Mountains, when high, or even of only moderate size, affect strategy, principally for the reason that the country in their neighbourhood is certain to be ill-adapted for the movement of troops. This fact, while it renders attack so difficult that defence is necessarily easy, yet reduces the latter to a passive resistance, and renders it possible for the assailants to manœuvre the defenders out of positions in which it would be madness to attack them. For these reasons, and also because of the comparatively small extent of mountainous country on the globe, and the poverty of the resources of such a country, it is evident that the grander and more important scenes of war will be played on ground better suited for their development.

Mountains therefore act principally as obstacles, forming either strategical fronts, lines of defence, bases of operations, or pivots for one or other flank of an Army, and their advantages for such uses are derived from the delay which their character imposes upon an enemy.

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For it must not be imagined that any line of mountains is absolutely impassable, even though it be obstinately defended; while if it were possible to find such a line, its value would be doubtful, since, in order that a defender may reap real advantage from his position, he must have exits from it, along which he may in his turn attack. If, therefore, we imagine two Armies, separated by a chain of mountains, it is evident that great advantages for attack or defence will lie in the hand of that which holds the passes issuing towards the enemy. If a chain of mountains bounding the theatre of war runs parallel to the line of operations (as would the Alps to an Army moving east along the right bank of the Danube) it will serve to cover the flank; if on the other hand it runs through the centre of the theatre, it, if extensive and high, cuts the latter into two distinct parts, or if smaller, offers to the Army which possesses the passages, the power of striking on either side an enemy who must guard both. In the first case, the safety of the Army, in the second, the victory, will depend upon the possession of the exits from the range; these exits or passes run invariably over the lower portions of the chain, and follow the lines of the valleys,[1] that is to say, the course of the streams; so that practically by mounting along the course of one river, and descending along another, we cross the chain by the shortest and easiest road. And in this fact lies the great value attached to the military possession of the heads of river valleys.

As an example, may be quoted the Pass of the St. Gothard, which is formed by the Reuss, and within a short distance of which rise the Rhine, giving access to north France and Germany; the Rhone, leading into south France, and the Inn, which, running into the Danube, gives access to the whole of the immense basin of the latter; while, having crossed the summit of the Pass, the traveller descends by the side of the Ticino into the valley of the Po.

The points of passage through a mountain chain are generally few in number, which at first appears favourable to the defence, but the nature of the country renders the relief of troops, the supply of provisions, and inter-communication so difficult that the advantage is much diminished.

To sum up, mountains parallel to the line of operations may serve to cover a flank; those at right angles to the line, may be used as a base or as a line of defence, but to an attacking force are an obstacle to be surmounted; and in each of these cases the effect is produced by the delay caused by the character of the ground, and not by any absolute impracticability for troops.

(6.) Rivers derive their importance in Strategy from two conditions, first, from their peculiar physical characteristics (as length, depth, character of banks, &c.), and secondly, from the direction of their course in relation to the line of operations of an Army.

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[1] We have no exact equivalent for "Thalweg," for "valley-line" does not quite accurately represent the opposite to "Watershed."

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The first condition may be known from maps or by reconnaissance; the second may be roughly divided into two cases:—

1. Where the river is parallel to
2. When it is at right angles to

} the line of operations.

1. A river parallel to a line of operations covers a flank, affords a means of transport, and leads the march on the best points of transit through its watershed.

If the river cuts the theatre of war into two parts, the Army which holds the passages can on either bank throw its whole strength upon a divided enemy.

2. A line of river at right angles to the line of operations may serve as a line of defence, a base of operations, or may be used to cover a strategic movement.

When a river forms the frontier between two States, that power will have the advantage whose bank commands the other; but if one of the nations possesses the farther bank of the river, even if only for a short distance, the advantage is still greater; since, if on the defensive this portion flanks the river-line, while if it be intended to attack, the passage of the river is secured.

If a river (as the Rhine at Bâle) makes a sudden change of direction, the defender in the re-entering angle can indeed act on interior lines, but is in danger of being cut from his base by the concentration and passage of the enemy on one of his flanks; as for example, in the campaign of Moreau in 1800. The junction of two or more rivers is always an important point, for its possession allows a force to act on interior lines against the enemy's troops as they descend the several valleys, or to strike at their flanks from the outer side of the sector; of such a position Napoleon, holding the basin of the upper Seine, made remarkable use in 1814, against the allies advancing up the Yonne, the Seine, the Marne, and the Oise.

(7). Valleys owe their existence to the reciprocal action of rivers and mountains, they follow the former and are the natural roads through the latter; they are, as it were, great arteries running from precipitous heights into the river-basins in which the fate of war is decided, and which contain the principal roads, railroads, population and wealth of every nation.

In every country which is not absolutely flat, the roads from one river-basin to another run along valleys on their way to the mountain passes, and it is therefore evident that in any war on a large scale, the question of the direction and character of the valleys must be specially considered.

Colonel Sironi considers that the characteristics of valleys may be distributed under four heads, viz.:—

1. Valleys which have their origin in the main chain of mountains, or in a secondary or tertiary chain.

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2. Valleys which are perpendicular or parallel to the main chain.

3. Convergent, divergent, or parallel valleys considered in relation to each other.

4. The length and width of valleys coming under any of the previous classes.

1. Primary valleys, leading up to the passes of the principal chain, are the direct roads between the opposite slopes of the chain; the most important roads run through them, generally along the bottom. The longer the valley the easier its defence, but the width of a valley scarcely affects the question, unless it be so narrow that the assailant cannot deploy his forces, in which case, the attack, even if it be successful, must greatly suffer, while the chance of failure is infinitely great.

2. Valleys perpendicular to the main chain mark the shortest road from the crest to the plain, and therefore offer to an invader the shortest possible line of advance through the mountainous country.

Valleys parallel to the main line lie between the main chain and a more or less parallel lesser chain, which must be occupied by an assailant before he can venture to advance along the valley, while the lateral passes of the lesser chain may be used by the defenders as sallyports from which to attack the enemy's communications. Such valleys are then very favourable to the defence, though should the assailant push rapidly down the main valley, he may at one stroke nullify the defensive dispositions of the surrounding secondary valleys.

Again, should the attacking Army have gained possession of a valley parallel to the main chain, it can, taking advantage of the direction and length of this valley, thence threaten the heads of all the valleys on the opposite slope of the mountain: but this advantage of course ceases to be, when the latter slope leads into another valley parallel to the main ridge.

3. Valleys parallel to each other, convergent or divergent.

Of convergent valleys, Colonel Sironi distinguishes two kinds:—

a. Large valleys which converge on a vast common plain, such as the Alpine valleys which lead into the basin of the Po.

b. Smaller valleys which converge on a deep primary valley.

a. In this case the offensive, starting from the periphery and descending the converging valleys, can envelop the defender, should the latter make the mistake of endeavouring to guard every passage; an example of such action is to be found in the Prussian advance into Bohemia in 1866. But on the other hand the defender can move on interior lines, and should be able to strike at the enemy's columns before they have succeeded in uniting, or in escaping from the defiles.

b. This case, to a great extent, offers the same advantages to attack and defence as *a*, but with this difference, that the defender has not

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the same facility of movement in the second as in the first case, since his position is in (*b*) a valley, more or less rugged and broken, while in (*a*) the ground is probably well suited for manœuvring.

The narrow parts of the principal valley are generally to be found a little below the point of junction of convergent valleys, and these parts in (*b*), as also the central points in (*a*), are usually held by a fortress.

In the case where a force occupying the central point of convergent valleys is about to assume the offensive, it has from its position the advantage that it can threaten simultaneously all the defiles leading towards the enemy, and can thus divide his attention. For example, from the Upper Po, an Army would threaten at once the Valais, Savoy, Dauphiny, Provence and Nice.

In the defence both of *a* and *b*, it is above all necessary to guard against the loss of the central point, and for this reason a force acting on the defensive must not allow itself to be pressed too closely, and must further distribute its reserves on a line which can communicate with the different convergent roads.

Divergent valleys, when used by an invader, afford an opportunity to the defence of acting on interior lines against his divided forces, but the possession of the central point from which the valleys diverge, gives the assailant the power of choosing that line of advance which offers the greatest chance of success, and further renders him comparatively secure from attack, while the defender is compelled to cover a large extent of country, or to leave some passages unwatched.

But divergent valleys are in truth simply convergent valleys looked at from another point of view, and what is true of the one is true of the other, substituting offensive for defensive, and *vice versâ*.

Parallel valleys which run at right angles to the strategic front offer a great advantage to the invader, since the defender must more or less scatter his forces in order to guard each road, and cannot, as a rule, collect his forces at any one point, except by marching his troops down one valley and up another; the assailant, on the other hand, can threaten all or any, and force one of the valleys.

Valleys which lie parallel to the front, or at right angles to the line of operations, offer a decided advantage to the defence, since they form, with the intervening ridges, a series of lines of defence, which must be attacked in front; for any turning movement would necessitate such a wide extension of the assailant's front as it would be difficult, if not dangerous, to execute. It is also possible for an Army which holds one of two valleys parallel to the enemy's line of operations to defend the other without actually occupying it, since the invader cannot venture to use the second until he has driven back from the first the force which would thence threaten his flank as he advanced.

Sufficient has perhaps been said to give a general idea of the character of the first or introductory part of Colonel Sironi's book, and we may be permitted to pass over a short chapter on roads, fortresses, and frontiers, since the Author himself appears to regard these as merely artificial accidents tending indeed to modify the

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strategical effect of mountains and rivers, but by no means to be compared with the latter in importance.

There is but little in the first part of the book which has not been already given to the world by previous writers on Strategy; but Colonel Sironi is undoubtedly wise thus to introduce his work, since the study of any art requires a previous knowledge of its rules and technical expressions.

The second part contains an account of the geographical condition of central Europe, considered strictly from a strategical point of view, the political question being entirely excluded.

The third part consists of a yet more detailed account of the Geography of Italy, the Author's native country, while the fourth describes the geographical relations which exist between the several European states, by reason of the effects on strategy of their several frontiers.

We propose, since our space will not permit of the analysis of the whole of this mass of matter, to exclude altogether the third part from consideration, and to choose in the second and fourth parts such portions of the work for special treatment as refer to the relations to each other of France and Germany, since the war of 1870 in the past, and its probable sequel in the future, have invested the struggle between these nations with a universal interest.

The general theory on which Colonel Sironi founds his scheme of strategy appears to be as follows:—

The great river-basins of Europe are, and always will be, the theatres of European war; these are separated from each other by watersheds, that is, by mountains or hills of a greater or lesser height, which are an obstacle to an attacking, and a defence to a resisting army; the river-basins contain, in addition to the grand principal river, a number of minor streams, tributaries of the former; the upper course of the great river and of each tributary forms a secondary valley; and finally it is by these valleys that the intervening mountain chains may most easily be crossed.

From these statements it follows, since a mountain chain varies in strategical value in proportion to the number of its passes,[1] and these passes are marked by the course of the streams which run from them, that the direction of rivers need alone be studied by an observer who wishes to learn the line which an army must follow from a given base to a given objective.

For in every war it will be necessary for the invading army to march from the river-basin which is its home, and to cross at least one line of watershed, in order to arrive at the river-basin in which its objective will lie; to do this it will follow its native river or one of its tributaries to its source, will cross the chain of hills or mountains, and thence descend the course of the enemy's river. Even in the cases (such as that of the Rhine in the event of a war between France and Germany)

[1] For a mountain chain which had no passes, if such could be, would act as a wall, preventing any contact, hostile or commercial, between the nations which it would eternally divide.

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where this theory will not hold good on account of the direction of the course of the great river, yet as regards the minor rivers it will still be true. For example, the basins of the Oise, the Marne, and the Seine will all be entered by an enemy advancing on Paris, while those of the Lahn, the Mein and the Neckar will lead a French Army from the Rhine into Germany.

If this theory be admitted as true in the main, we may deduce from it another, namely, that the decisive battle or battles, will be fought in the great river-basin, since only there can sufficient space be found for the deployment of modern armies, while the preliminary combats will take place on or near the water-shed; and further, that the march of the invading Army from the water-shed to the field of battle, and from the latter to its objective will follow with little variation the great river line.

Of such a theory, the campaigns in the basin of the Danube of 1805 and 1809, and in the basin of the Po in 1796, 1800 and 1859, are good examples.

To return to Colonel Sironi's book: we find that the first instance which is given of the fact that advancing armies follow river lines, is taken from the itinerary of the great invasions of Europe from Asia, and these it may be well to examine.

The nations of Asia have at various periods broken forth from their continent upon Europe on three principal lines, viz.:—

I. From Asia Minor across the Hellespont or the Bosphorus.

II. From Turkestan by Armenia and the Caucasus.

III. From Tartary across the Ural Mountains.

I. The invasion which crossed the Straits from Asia Minor into Thrace, after reaching Europe divided in three directions, viz.:—

a. To the left, along the Ægean Sea, by Macedonia, Thessaly and Epirus into the Peloponnesus, thus following the sea coast.

b. To the right, along the Black Sea, on to the Danube and Southern Russia.

c. The principal line of invasion, continuing its course on the centre of Europe, followed the Maritza to its source, there crossed the Balkans, and thence marched by the Morava on the Danube. It here divided into two parts:—

(*a.*) Which followed the Danube through Hungary on central Europe, and

(*b.*) Which, turning to the left, followed the Save and the Drave to the Julian Alps, to Italy and Southern Europe.

This line of invasion was that selected by the Turks, who penetrated into Styria by route c (*b*), through Hungary to Vienna by route c (*a*), as far as the Pruth and the Dniester by route b, and subjugated the Servians, the Bulgarians, and finally the whole of the Greek Empire,

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II. From Turkestan by Armenia and the Caucasus. This line of invasion having crossed the Caucasus, found its march interrupted by the Don, it therefore here divided into two parts, viz. :—

a. Which followed the shores of the Sea of Azoff, crossed the Don, the Dniester, and the Pruth, passed into Wallachia along the edge of the Black Sea, and was then broken up by the Carpathian mountains into two parts; (*a*) which bent southward into the valley of the Danube, and (*b*) which turned to the North towards the Vistula.

b. Which, crossing the Don, followed the Donetz to Kharkov, and thence by two routes followed the Dnieper to the Vistula.

III. From Tartary across the Ural mountains. Two routes cross these mountains, viz. :—

a. The grand road from Tobolsk, which passing the frontier at Ikaterinsburg, leads along the Biela to Kazan on the Volga; thence by the Upper Volga to Moscow, along the Moskwa on Smolensk, thence (*a*) on Wilna, or (*b*) by Minsk on Brzec-Litewski; and so into the valley of the Vistula.

b. Various roads from Central Asia unite at Orenburg, and pass either (*c*) by Samara on Moscow, or (*d*) by Penza, the Valley of the Sura and Orel, on Bobruisk.

It will be observed that these lines of invasion, omitting the conquest of the East by the Turks, may be divided into three great lines, viz. :—

A. The Southern, which marched by the Save and the Drave into the basin of the Po.

B. The Central, which ascended the basin of the Danube to its source.

C. The Northern, which from the Vistula overran the great Plain of North Europe as far as the mouth of the Rhine.

Following out this theory, Colonel Sironi divides his chapters on the Strategical Geography of Europe under three heads,—

1. The Northern region, including the basins of the Vistula, the Oder, the Elbe, the Weser, and the Lower Rhine.
2. The region of the Danube.
3. The Southern region, including the upper Save, and the upper Drave, and the lower Rhone.

He also devotes two chapters to the consideration of the middle Rhine, and the river-basins between that river and Paris, and it is this portion of the work that we propose more particularly to consider.

The "middle Rhine" extends from Bâle, at which point the river turns suddenly towards the north, as far as the junction of the rivers Ruhr and Lippe, a distance of about 320 miles. This portion may be

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conveniently divided into two sections, of which the first, between Bâle and Mayence, runs through the plain which lies between the Black Forest and the Vosges, while the second, between Mayence and Dusseldorf is confined by the Taunus, Westerwald and the Hochwald on the right bank, by the Hundsruck and the Eifel on the left, so that between Bingen and Coblentz the river runs through a defile.

In the first section, after Bâle, the principal bridges are at Strasbourg, Maxau (near Carlsruhe), Mannheim and Mayence; the banks of the river are in many places marshy, and, in spite of the existence of many islands, and of many points suitable for passage, the Rhine must always be an important military obstacle. The plain, which extends from the Black Forest to the Vosges varies in width from 12 to 30 miles, is rich, populous and well adapted for the movement of troops. It is however too small to contain the large armies of the present day, but would make an excellent base for an Army advancing from it either eastwards or westwards.

Defensive positions against an attack along the river valley are afforded by the Elz, Kinzig, Rench, Murg, and the Lower Neckar on the right bank, by the Moder, the Lauter[1] and the Queich on the left, but with the exception of that of the Neckar, these river lines can all be turned by the high ground in which their sources lie.

In the southern portion of the first section, there are three important points, viz. :—Bâle, the terminus of the line of railway on the right bank; Mulhouse, the junction of the railroads, Bâle-Belfort, and Strasbourg-Altkirch, and the centre of the roads which lead from the basins of the Aar and the Saône into the Plains of Alsace; and Altkirch, which it was at one time proposed to convert into a fortress, with the objects of covering Belfort, and of closing the passage between the Vosges and Alsace.

The principal fortresses in this section are Strasbourg, Neu Brisach, Germersheim and Rastadt, but of these Strasbourg alone has much value at the present time. This last is the centre of the communications which run from the Vosges to the Rhine, and covers the Black Forest from a French attack.

The Vosges attain their greatest height at their southern extremity near Belfort, and are, for a distance of about 60 miles, so rugged and wooded that they form a strong line of defence; but further to the north they sink gradually into the plain of the Rhine. They are crossed by four good roads, viz. :—

a. From Mulhouse, by the passage de Busang, to the sources of the Moselle, thence on Epinal and Nancy.

b. From Colmar; c. From Schelestadt; and d. From Strasbourg. These three roads join on the Upper Meurthe, and lead by Lunéville on Nancy.

The railway between Strasbourg and Nancy passes through a valley, (covered by the small fortress of Phalsbourg); the prolongation of

[1] Before 1870, the boundary between France and the Palatinate.

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this valley leads on the defile of Pforzheim, which from Carlsruhe runs into the Black Forest. To the North of Phalsbourg the Vosges become less rugged, more open, and more populous, but still offer good defensive positions; on the crest of the range stands the fort of Bitsche which covers the Haguenau-Metz railway.

Beyond the Lauter rise the mountains of the Palatinate, and these extend as far as Mayence, of which the outworks are erected on the most northern spurs of the range. Many roads lead from the Rhine by Wissembourg, Landau, Spire, Mayence, and Bingen, and running by Zweibruchen and Kaiserslautern, join at Saarbruck, and thence spread out on Metz, Nancy, Thionville, and Tréves. Kaiserslautern is the most important point on these roads. The mountains of the Palatinate are joined to the Hundsruck by a low range which runs between the Rhine and the Moselle as far as their junction. An Army posted in the region of the Hundsruck could thence strike at either side of the Vosges, towards the Rhine basin, or towards the plateaux of Lorraine, and could manœuvre in one body against an enemy who would be divided by the Vosges.

From the southern Vosges a chain runs to the west, which forms the watershed of the Moselle, the Meuse, the Marne, the Aube, the Seine and the Saône; this is called the Monts Faucilles, and has no great value as a defensible obstacle, while it leads directly from the Rhine to the Seine. The western slope of the Vosges falls on to the high plateau of Lorraine, which is intersected by the courses of the Moselle, the Meurthe, and the Saar, as well as by numerous deep and narrow valleys, but the communications are so good that military operations in it are easy. This plateau is bounded on the west by the mountains of the Meuse and by the Argonne, which last was thickly wooded and almost uninhabited, but has lost much of its value as a military obstacle, owing to increased culture and the destruction of much of the forests.

To return to the Rhine valley: the second section of the river, from Mayence to Dusseldorf is about 120 miles in length, and is crossed by permanent bridges at Coblentz, Cologne, Dusseldorf, Duisbourg, and Wesel.

The river between Mayence and Cologne is shut in on either bank by high hills, which, though productive near the stream, are sterile as regards their upper plateaux; it is crossed by few roads, and these are for the most part covered by the fortresses at Coblentz, Cologne, Mayence or Wesel. This second section is for the above reasons, of all the Rhine, that portion which offers the fewest facilities for attack, and a wise commander would prefer to select his points of passage either in the first section or on the lower part of the river.

In the latter case, the river itself would certainly be a greater obstacle to an advance, but its passage would open out to him the possession of the great Belgian and German plains, in which he would find roads, supplies, and due space to manœuvre; the former has few fortresses of any importance, is far richer in resources, and as regards the actual stream, offers many facilities for passage, as the islands are numerous, the banks are flat, and the course of the river so winding,

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that there can be no difficulty in selecting suitable positions for bridges.

The lines of operations which in the second section run parallel to the Rhine, are driven from the river bank by the fact that, in each case, the heights on the opposite side command the road, and they are thus forced, that on the right bank into the Taunus and Westerwald with their deep valleys and high hills, that on the left bank into the no less unfavourable ground of the Eifel and the Hundsruck. The former road crosses the Lower Mein, the Lahn, and the Sieg before it rejoins the Rhine at Cologne, after which city it has to pass the Ruhr and the Lippe; the latter leaving the Rhine and running towards the Saar, rejoins the former by the left bank of the Moselle, having crossed a country which has but little to offer for the subsistence of an Army.

The Moselle, flanked at its source by the southern Vosges, and at its mouth by the Fortress of Coblenz, the centre being strengthened by the Hundsruck and the Eifel, as also by the strong places of Thionville, Metz and Toul, would be a line of defence of immense strength, useful to cover either the Palatinate or the basin of the Seine, were it not that its upper waters being French, and its lower German, this line is completely turned; while as regards France such a partition is a source of great danger, since the Moselle now offers a direct road to the Seine.

The Meuse runs between the Argonne and the Ardennes; its banks are at first steep, and later marshy, while its bed is wide and deep. Like the Moselle it would, were it entirely French, cover and guard the basin of the Seine, but now, on the other hand, leads an enemy on Paris by way of the Sambre and the basin of the Oise.

We must now, omitting much that is interesting on the subject of the tributaries of these two rivers, pass on to consider the passages on the German bank of the Rhine.

This river, says Colonel Sironi, has the plan of a "*tenaille*," concave towards the west, and the point of junction of its two sides is at Mayence, which is also the centre of the whole middle Rhine. Placed as it is at the salient of the *tenaille*, and at the mouth of the Valley of the Mein, it must be the principal pivot of any operations on the east of the Rhine, since by that valley lies the best route of a force which proposes to break in between the Germany of the Weser and Elbe, and the Germany of the Danube. By fixing his base between Mayence and Mannheim, and making use of the various roads which lie before him, an invader will avoid the difficulties of the Black Forest, or those of the Weser and its mountainous watershed, and can push forward easily on the Danube or on the Elbe as he shall please.

If, however, it be determined to attack South Germany alone, the assailants will advance by the Valleys of the Murg, the Kinsig, the Rench, the Elz, or the Swiss Rhine; if, on the other hand, Berlin be the objective, the Valleys of the Lahn, the Sieg, and the Ruhr are open to the invader, with the lines of rail which lead across the basin of the Weser on the Elbe, Magdebourg and Berlin.

But whatever may be the plan of invasion, that part of the Rhine

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between Mannheim and Mayence will give the direction of a line of operations which can converge on either of the others, and must be, strategically speaking, the most important of the three. Napoleon III., in 1870, proposed to cross the Rhine at Maxau (near Carlsruhe), and thence moving to the Mein, to interpose 250,000 men between North and South Germany.

Mayence has also a great strategical value as regards operations carried westwards from the Rhine, since it offers the most direct road on Paris, the necessary objective of such operations, and is also in front of the more accessible country which lies between the heights of the Vosges and the Hundsruck.

If we next examine the various lines available for operations between the basin of the Rhine and that of the Seine, we find,—

1. That from Bâle by Belfort, Langres, Chaumont and Troyes, which has a length of about 350 miles. This route turns the line of the Vosges, and the basins of the Moselle, the Meuse and the Marne, but to use it necessitates the possession of Bâle. It crosses the deep valleys of the Oignon and the Saône, and traverses the Faucilles, which offer a strong strategic position covering the centre of France, and are supported by the fortress of Langres. But Belfort, standing directly on the principal line of operations, is a most important obstacle, commanding, as it does, the open country between the Vosges and the Jura; this fortress may, however, be turned at the expense of violating Swiss territory, by the road from Bâle to Porrentruy.

2. From Strasbourg by Nancy on Vitry-le-Français, and thence, leaving the railroad, by Coulommiers on Paris; this line has a length of about 280 miles. It is crossed by the Vosges, and by the Moselle, the Meuse and the Marne, but not one of these is an obstacle of any great value. The most important points on the route are Lunéville, Nancy, Toul and Vitry-le-Français, of which the two latter are fortified.

3. From Mayence by Saarbruck, Metz, and Verdun on Châlons (about 320 miles). Two railroads, one from Mannheim, one from Bingen, lead on Saarbruck, after which this route meets with considerable obstacles in the Moselle, the Meuse, and the Forest of the Argonne. Saarbruck, Metz, Thionville and Verdun are the principal strategical points on the line, of which the first three are German, while the three last are fortresses.

4. From Coblentz by Trèves and Luxembourg, by Stenay on Rheims (about 290 miles). On this line there is no direct railroad, except between Trèves and the Meuse. The route crosses the southern end of the Eifel, avoids the Moselle and the Vosges, but has to cross the Argonne and the Aisne. The principal points on this line are Luxembourg, and the French towns of Stenay and Rheims. It may be here mentioned that both the tactical conditions of Châlons, and its strategic importance, with regard to the three last named lines of operations, render it a desirable position for an entrenched camp covering Paris.

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5. From Cologne and Dusseldorf along the right bank of the Meuse, by the northern side of the Eifel and of the Ardennes, through Aix-la-Chapelle on the French towns of Givet, Laon and Soissons. The principal obstacles are the Roehr and the Ourthe (of which the beds are deep and the banks wooded), the Meuse, which is very wide with scarped banks, and the Aisne, which though small runs through steep ravines. Givet, Mézières and Soissons, though not of any great strength, may yet delay the advance of an army using this line. Aix-la-Chapelle, and Laon are also important strategical points.

6. From Cologne-Wesel by the valleys of the Sambre and the Oise. This line crosses the Meuse at Maëstricht, and runs along its left bank between it and the Scheldt, through a rich and populous country, free from important obstacles, and thus by Charleroi, Maubeuge and the Oise on Paris. The Fortresses of Maubeuge, Valenciennes, and Lille form the principal obstacles on this route, which would probably be used in conjunction with route (5) since the Meuse-Sambre-Oise railway would serve them both.

It is necessary to draw the reader's attention to the fact, that in order to make free use of route (1) Swiss neutrality must be violated,[1] and that unless Belgium be coerced or cajoled, routes (5 and 6) will lead through hostile territory, and further that route (4) implies the possession by the invading power of Luxembourg, which is at present on Dutch territory.

Colonel Sironi in his chapter on the basins of the Seine and the Saône, which we have not space to consider in detail, decides that between the existing German frontier and Paris there is, now that the Vosges have been lost to France, no natural military obstacle of importance which could delay the march of an invading army, while the situation of Paris is such, that a force which is besieging that city finds in every direction roads along the river basins, suitable for the purpose of despatching detachments which may be required to act in any other part of France. With regard to the valley of the Saône he remarks that a French attack from the south might, advancing up that river, turn the line of the Vosges by way of Belfort.

It may be well now to endeavour to work out (for it is not distinctly given by Colonel Sironi,) the character of the various routes which would be followed by an enemy who should invade Germany from the west. The principal lines of operations available to an advancing Army will follow in great measure the main lines of railway; if we examine these in order from the north, we find,—

(1.) The line between Duisbourg and Berlin.

This leads up the valley of the Lippe, and turning the Ems by the Teutobergerwald (of which the hills, though of no great height, are wooded, and being divided by deep valleys, are not suitable for large

[1] The Rhine may be crossed at Huninguen, but even in that case the use of the railway station at Bâle will be still necessary.

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military operations), meets with its first important obstacle at the Fortress of Minden, which is situated on the left bank of the Weser, at the point where the latter leaves the mountains. The line of the Weser is not stragetically strong, as it can easily be turned, but nevertheless it is of some value, since its upper course runs through broken and wooded country, while its lower stream is wide, and runs through marshy ground. Its basin leads into the basin of the Mein by the Fulda and the Werra, and into that of the Elbe by the Aller. The next obstacle to the march is found on the line of the Elbe, of which the banks are very marshy, and of which the passage is flanked by the strong Fortress of Magdebourg, while the country between the Elbe and Berlin is cut up by canals, lakes and marshes, so that the river is not easy to cross, nor is the eastern bank favourable to the action of large bodies of troops.

(2.) The line from Dusseldorf by Magdebourg on Berlin.

This follows the line of the Ruhr, crosses the upper Weser, and passing along the northern side of the Hartz mountains, runs directly on Magdebourg, which place must be reduced before the passage of the Elbe be possible. It will thus be seen that a force using this line of operations will meet with no great natural obstacle, but if it be acting in connection with a force advancing by,—

(3.) The line from Cologne by Cassel on Leipsic or Berlin,

the two armies will be divided by the Hartz Mountains, and may be defeated in detail by a force of the defenders which moves from Magdebourg.

The railway runs up the valley of the Sieg to Wetzlar, and thence along the Lahn towards Cassel, and a force which should endeavour to move on the hypothenuse of the triangle Cologne-Wetzlar-Cassel would be forced to cross the rugged and sterile heights of the Westerwald and the Rothaar. At Nordhausen the route touches the southern edge of the Hartz Mountains and, whether it leads on Berlin or through Leipsic or Dresden, must in either case cross the Saale. This river runs in a deep bed, and is a considerable obstacle, while an army which attempts its passage exposes of necessity its left flank to an attack from Magdebourg and the lower Elbe. The Saxon frontier is crossed a little to the west of Leipsic, and the invaders would then find themselves in a rich country supplied with numerous communications. Dresden is, after Magdebourg, the most important point on the line of the Elbe, but is not fortified. The principal fortresses in the system of that river are Königstein, which is impregnable, but of so little strategical importance that it was entirely neglected by the Prussians in 1866; Torgau and Wittenberg, between the Saxon frontier and Magdebourg; and Erfurt in the valley of the Unstrutt covering the passages of the Thuringerwald.

(4.) The line from Coblentz, which joins (3) at Wetzlar.

(5.) The line from Mayence, by Frankfort, into the valley of the Mein.

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This route, as has been previously shewn, is of the highest strategical value, and must be the principal line of advance from the west into Germany. The valley of the Mein is bounded on the south by the Odenwald, a range of sterile hills which is difficult of passage, but being of small extent, is easily turned; on the north by the Spesshardt, which is a range with an average height of 2000 feet, and possessing but two roads. These mountains form an obstacle of no great value, as they can be easily turned by the lower Neckar, or passed by the Mein. The bed of the Mein is deep, and it runs through many narrow gorges, but it has many fords and permanent passages, and is followed by numerous excellent roads. An Army may move from its valley into that of the Saale by way of the Unstrutt, or into that of the Weser by the valley of the Fulda. The country between the Mein, the Böhmerwald and the Danube offers no considerable obstacle to military operations, since the courses of most of the tributaries of the latter river by their direction serve rather than obstruct a march from Bamberg or Nuremberg on Ratisbon.

(6.) The line from Mannheim on Nuremberg follows the watershed between the Mein and the Neckar, avoiding all rivers, and meeting with few obstacles of any importance.

(7.) The line from Carlsruhe, by the valley of the Neckar on Ulm.

The Neckar running between the Black Forest and the Suabian Alps, affords many good defensive positions, but it has numerous passages, its stream is shallow, and the slopes of the Black Forest are easily accessible.

Ulm is a point of very great importance, and is the centre of a strong defensive line which extends to the Suabian Alps on the right, and following the course of the Iller on the left, closes the valley of the Danube. Other important points in this theatre are Frankfort on the Mein, Bayreuth, Bamberg, Wurtzbourg, and Nuremberg.

(8.) The roads through the Black Forest.

The principal roads are four in number, viz. :—

(*a.*) The road and railroad between Bâle and the Lake of Constance, which pass along the right bank of the Rhine, between the river and the steep southern slopes of the Black Forest, and come out on the Upper Danube about Engen and Stokach.

(*b.*) The route of the valley du Drysam or de l'Enfer, from Neu Brisach to Donaueschingen; this is the shortest of all, being only two marches in length.

(*c.*) The route of the Kinsig, from Kehl, through a populous and less narrow valley than the former; it divides at Hausach, one road leading on Donaneschingen, the other towards the Neckar.

(*d.*) The route of the Murg, which however leaves the left flank of an invader exposed to attack from positions which the defenders can occupy.

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Above the Murg the Black Forest has little value as a military obstacle; it is altogether about 130 miles long by 50 wide, and though everywhere passable by Infantry, is not easily traversed by wheeled vehicles; its valleys are deep, and along these the roads run; it, by its position, turns the source of the Danube, but is at that point so wooded and sterile that large armies are likely to prefer to pass on lines to the north or south of it, and thus to outflank the strong positions which the Black Forest offers to its defenders. Rastadt is at present the only fortress on this front, though it has been at different times proposed to fortify Freibourg, Donaueschingen and Stokach. It may be well, before quitting this portion of the subject, to mention that, should the French venture to violate the neutrality of Switzerland, another road is available for their use, namely that from Besançon and the valley of the Saône, through the passes of the Jura and the valley of the Aar, on Schaffhausen and Lake Constance, and then into the Danube basin by Stokach; this is the route which was used by Moreau in 1800.

Having given this example of the manner in which Colonel Sironi treats the subject which he has selected, it may be interesting to many to refer shortly to a chapter in the latter portion of the work in which he considers, with reference to the present French and German frontier, the probable course and result of a new war between these Powers.

The Franco-German frontier has a length of about 190 miles; it joins the Swiss frontier near Belfort, and, leading straight to the Vosges, runs along the crest of that chain to about the level of Strasbourg; at this point it bends to the west along the watershed of the Sarre, crosses the Moselle a few miles below Pont à Mousson, and passing 9 miles west of Metz, and 10 miles west of Thionville, meets the Belgian frontier near the junction of the latter with that of Luxembourg. This line is, on the German side, strong by its natural formation, as well as by the presence of the fortresses Metz and Strasbourg, and its one weak point, namely the space between the Vosges and the Jura which is threatened by Belfort, may be easily strengthened by fortifying Mulhouse or Altkirch; while Strasbourg is near, the Rhine is a serious obstacle to an advance, and above all this weak spot is not in the direct line of operations.

France on the other hand, having lost the strong defensive lines of the Rhine, the Vosges, and the Moselle, is compelled to entrust her defence to a network of fortresses, on the construction of which she is reported to have spent 1,300,000,000 francs.[1]

The defensive position of Germany in the event of a fresh war, is therefore secured by natural and artificial obstacles of great value, or should she, as is more probable, assume the offensive, the fact alone that she starts from Metz, instead of from the Rhine, gives her a clear gain, and causes a distinct loss to the French, of about 10 days.[2] She stands in the heart of France, and has no natural obstacle of any

[1] £52,000,000.

[2] Wissembourg was fought on the 4th August, and Borny on the 14th August, 1870.

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importance between her and her objective Paris, while from that point, she can, thanks to the river-formation of the country, with ease control the efforts of the French provincial Armies, which must move on exterior lines, and can scarcely hope to act in unison.

France, acting on the defensive, must endeavour to gain, by means of her fortresses, sufficient time to assemble her Army between Metz and Paris; at some point in this interval, possibly at Châlons, a great battle will be fought. If in this the French are defeated, nothing remains to avert a new siege of Paris, of which the result is almost certain to be the same as before, unless indeed the French capital be saved by foreign intervention. Or, on the other hand, let us suppose that France, abandoning her new fashion of fighting in defence, reverts to Napoleonic tactics, and assumes the offensive, either at the commencement of the campaign, or after having gained the battle of which we have just spoken. Where shall she attack?

The frontier forms a re-entering angle, of which the apex is covered by Strasbourg, and this frontier is so shut in by Switzerland on the south and Belgium on the north, that it cannot be turned, but must be attacked in front.

The direct line from Paris on Berlin leads by Coblentz or Cologne, but to arrive at these points the French must either violate Belgian territory or pass Metz; and, whichever of these horns of the dilemma she may seize, she will yet have before her the passage of the Rhine, the two fortresses above-named, and that of Mayence in addition.

Like the proverbial fox when the grapes are out of reach, France may then declare that Berlin is not her objective, but that she wishes to advance by the valley of the Mein between North and South Germany. In this case, she must either attack Metz, a proceeding which would retain her Army for a long time, and enable Germany to regain the initiative, or she must turn Metz and move on the Palatinate, by which movement the right flank of the French Army would be exposed to a counter-attack from Strasbourg and the Southern Vosges, and would further be obliged to move over very broken and rugged country, full of good defensive positions.

Again, if France determines to attack the salient of the frontier or its southern front, her Army has then Strasbourg or the Vosges in its front, while a counter-attack from the northern front would sweep down on its exposed left flank; and, if all these fail to stop the advance, there remains yet the passsage of the Rhine to be effected. If attacks be delivered simultaneously on all these points, Germany, taking advantage of the necessary dissemination of the French forces, will in her strong position, hold some portion of the latter, while her Army will break out probably from Metz, and move directly on Paris.

The only point at which a successful result appears possible to a French attack is that before mentioned in front of Belfort; but should this attack be made in great force, it would leave Paris and Northern France entirely uncovered, while it is difficult to see what corresponding advantage would accrue to the French, since the only result of such a movement would be to turn the line of the Vosges, unless indeed France should violate the neutrality of Switzerland, and press on

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through the valley of the Aar into the basin of the Danube; but even this latter plan would be dangerous, if not impossible, unless the German Army had first sustained so heavy a defeat, or series of defeats, that it was no longer capable of assuming the offensive.

We may conclude, then, that France, except she obtain allies, should not venture to engage in war with Germany, unless the latter be divided by internal dissensions; and that given one or other of these conditions, even then France cannot venture on a strategical offensive until she has tactically defeated the German Army.[1]

With regard to the general character of the book, it appears to be a most valuable work of reference, compiled with great care and industry, and containing a very large amount of information, but it sadly wants an index of proper names, its plan is not always very clear, in many places (perhaps by the fault of the translator), its meaning is exceedingly indistinct, and—gravest fault of all—it has no map. No one could dream of reading such a book from end to end, but as an assistance to the study of a past or possible future campaign it is very superior to the majority of works of its kind; to be appreciated it must be studied, and be studied with a map, without which it has no more value than the Index of an Atlas.

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[1] It is but fair to Colonel Sironi that I should acknowledge that he is responsible only for the facts given above; the deductions, such as they are, are my own.

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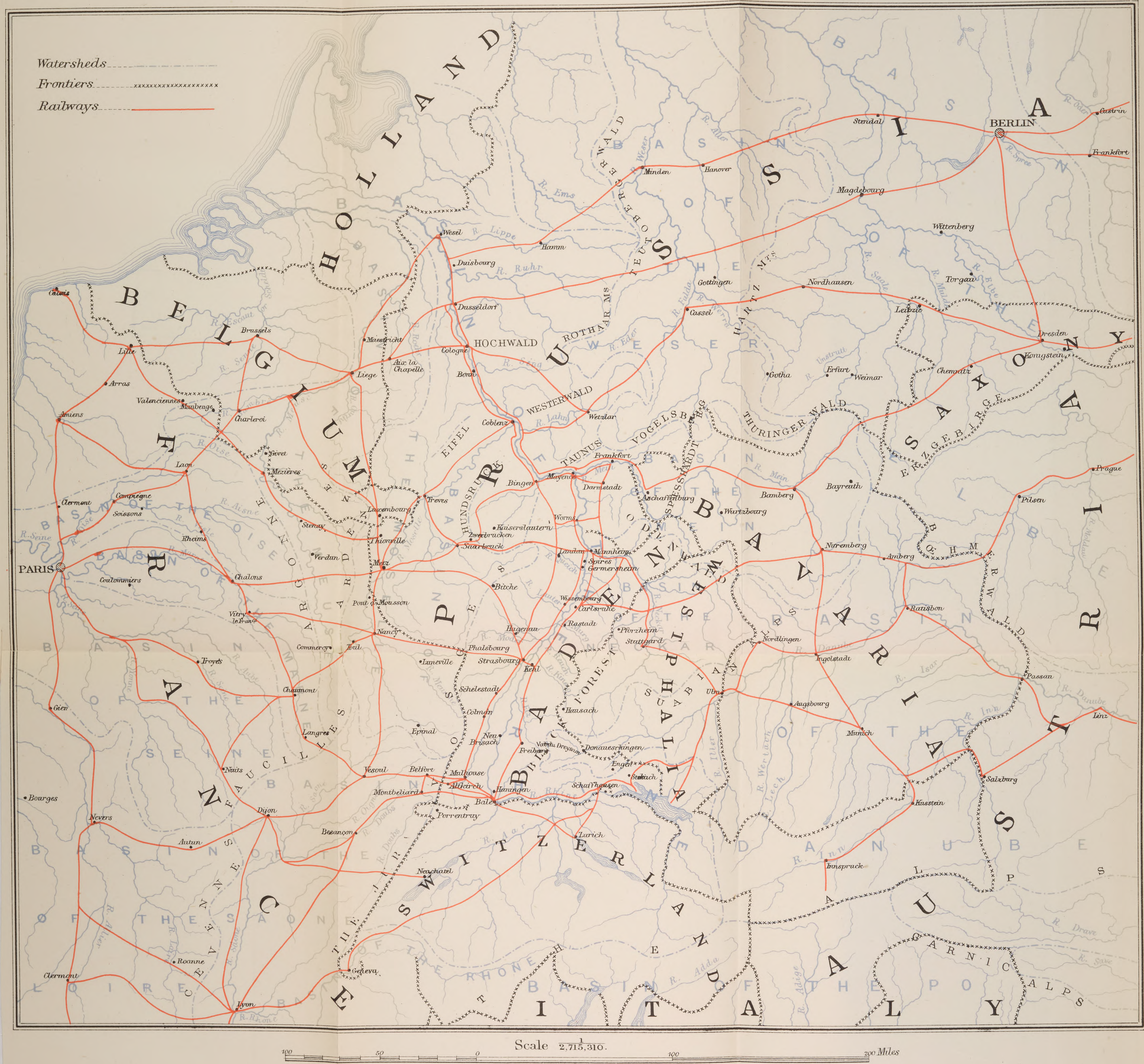
RIVER SYSTEM OF WESTERN EUROPE.


Watersheds
Frontiers
Railways
HOLLAND
BELGIUM
FRANCE
GERMANY
SWITZERLAND
AUSTRIA
ITALY
BASIN OF THE RHINE
BASIN OF THE SEINE
BASIN OF THE LOIRE
BASIN OF THE GARONNE
BASIN OF THE RHONE
BASIN OF THE DANUBE
BASIN OF THE ELBE
BASIN OF THE ODER
BASIN OF THE WESER
BASIN OF THE EMS
BASIN OF THE MEUSE
BASIN OF THE SCHELDT
BERLIN
PARIS
Stendal
Minden
Hanover
Magdebourg
Wittenberg
Torgau
Nordhausen
Gottingen
Cassel
Leipzig
Dresden
Konigstein
Chemnitz
Gotha
Erfurt
Weimar
Eisenach
Frankfort
Prague
Pilsen
Bayreuth
Bamberg
Nuremberg
Amberg
Ratisbon
Passau
Linz
Salzburg
Kusstein
Innspruck
Munich
Augsburg
Ingolstadt
Nordlingen
Ulm
Stuttgard
Pforzheim
Carlsruhe
Rastadt
Wissembourg
Landau
Mannheim
Spires
Germersheim
Worms
Wurtzbourg
Aschaffenburg
Darmstadt
Mayence
Bingen
Wetzlar
Coblenz
Bonn
Cologne
Aix la Chapelle
Liege
Maestricht
Dusseldorf
Duisbourg
Wesel
Hamm
Osnabruck
Bremen
Hamburg
Lubeck
Rostock
Stettin
Posen
Breslau
Dantzic
Konigsberg
Memel
Warsaw
Petersburg
Moscow
Riga
Reval
Stockholm
Christiania
Copenhagen
Gothenburg
Malmo
Carlscrona
Wisby
Visby
Abo
Helsingfors
Wiborg
Tornea
Archangel
Vienna
Presburg
Buda Pesth
Hermannstadt
Bucharest
Jassy
Odessa
Kherson
Sebastopol
Simferopol
Kertch
Taganrog
Azoff
Rostoff
Tiflis
Erivan
Tabreez
Teheran
Ispahan
Shiraz
Bushire
Bussorah
Bagdad
Mosul
Diarbekir
Orfah
Aleppo
Damascus
Jerusalem
Gaza
Cairo
Alexandria
Tripoli
Tunis
Algiers
Oran
Tangier
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Mogador
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TWO-INCH COMBINED TIME AND CONCUSSION METAL FUZE.

BY

MAJOR G. B. MACDONELL, R.A.

LIEUTENANT PARSONS, R.H.A., in his most interesting account of the Battles of Laing's Nek, Ingogo, &c., expresses an opinion in which he advocates the introduction of a fuze which, when once fixed, could be rapidly altered from one range to suit another when in action against an enemy in motion. Early in 1880 I designed and caused such a fuze to be constructed, and in case the subject may interest any of my brother officers I forward a very brief general description and working drawings of this fuze.

It is made of bronze, and is shaped externally somewhat like the ordinary fuze in present use, except that the upper portion is cut with a screw thread to enter the bush of the G.S. fuze-hole, while the head has a dial engraved on the top, to the figures of which a moveable index pointer can be turned by means of a wrench or key in the possession of the No. 1.

The composition is pressed into a central tube down one side of which a slot has been cut, the composition must be so pressed that it will entirely fill up the *groove cut in the metal* of the tube, and be flush with its exterior surface. This tube having been coated with a solution of paraffin and ether, and dusted over with finely powdered graphite, is pressed into another tube made to fit it very accurately. This latter has a spiral slot cut through the metal, and is held firmly in the body of the fuze, while the inner one carrying the index can be turned round by means of the key. The point where the fire can escape into the body of the fuze is the intersection of the slots in the two tubes, and can be adjusted to any length by the key. Before filling with composition the tubes are fitted together, set to the zero point, where the slots are covered, and then subjected to high steam pressure in order to ascertain if they are perfectly gas-tight. They are held in the fuze by a *jamming collar*, which is kept in position by means of a small set-screw in the side of the head.

The concussion arrangement consists of a series of holes (only partially shown in the drawing) in the outer tube, and one in the inner, but separated by a portion of the metal in each. On impact the projecting central tube is driven down until the hole cut in it coincides with that cut in the exterior tube and opens a flame passage into the body of the fuze.

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The *jamming collar* has a small dial stamped on it, marked in seconds and quarters of a second, to which the inner part of the index pointer may be turned when the shell is fired with a reduced charge.

The head is covered with a screw cap to protect the dials, pointers, and safety-pin.

It is intended that these fuzes should be carried in the shells ready for immediate use when on field service, so that there need be as little delay as possible between the declaration of the range of an object and the discharge of a shot. The use of the safety-pin and screw cap renders this method of carriage quite safe.

The following is a list of the several parts :—

1, body; 2, bottom plug; 3, range or casing tube; 4, composition tube; 5, jamming collar and set-screw; 6, two metalline anti-friction rings (not shown in the drawing, but intended to be placed between the flanges of the tubes); 7, detonator box; 8, hammer; 9, safety-pin; 10, top plug and pointer; 11, screw cap for head (not shown in the drawing).[1]

Since the above fuze was designed a great many improvements have suggested themselves, among which is the use of a larger composition tube, so that the spiral and vertical slots may cross at a less acute angle, &c.; but I give this description and drawings from which the first fuze on this system was actually constructed, and shall be happy if what has been written above will be of any use to any of my brother officers who may take the subject in hand for further development.

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[1] The drawings are those from which the original rough fuze was made. Since then, when it was still in the workshop, the parts have been simplified, such as making the top plug and pointer in one to screw on to the head of the composition tube, enlarging the safety-pin and holes so as to permit of the free escape of the gas, &c.

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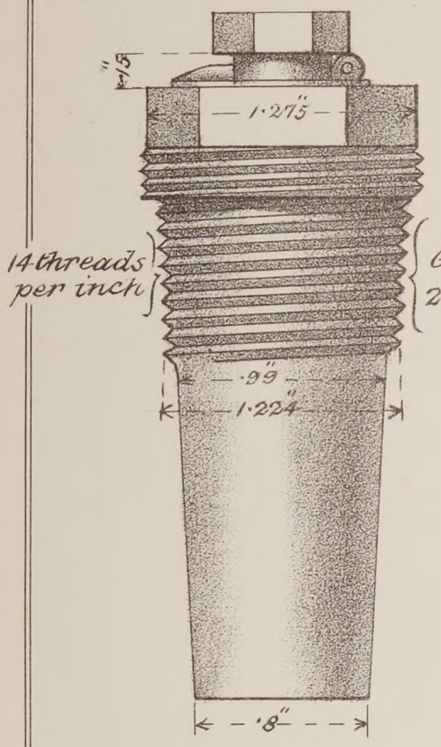
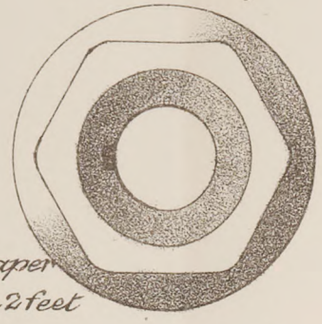
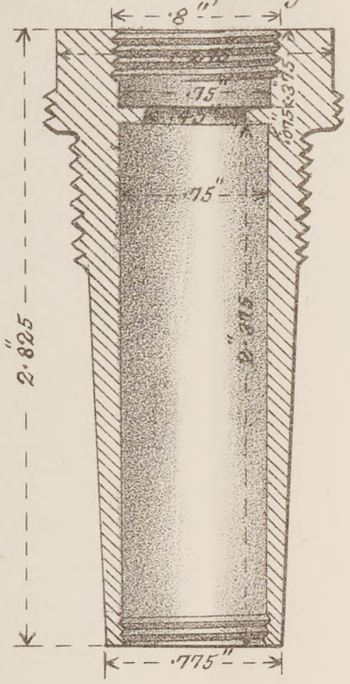
Exterior Elevation.

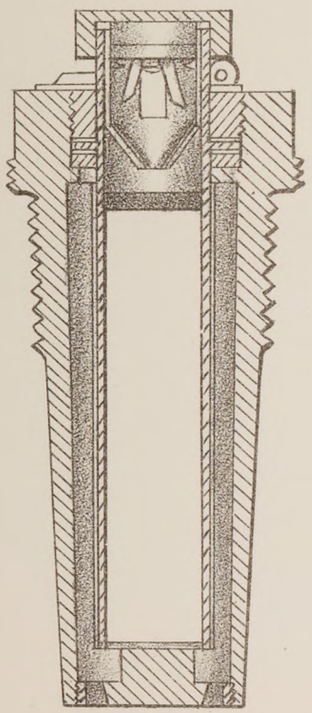


Plan, Body.

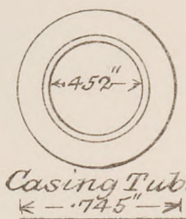


Section, Body.

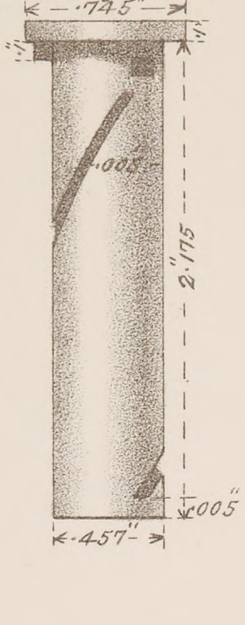




Plan

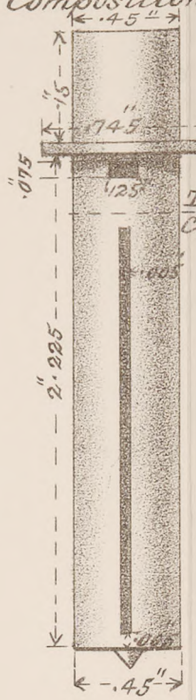


Casing Tube.



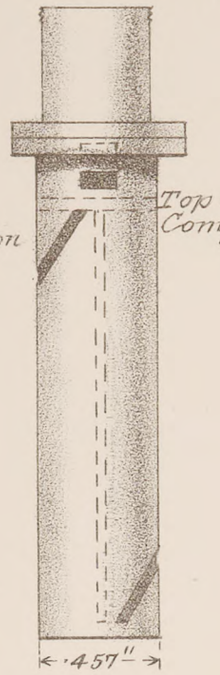
Plan.

Composition Tube.

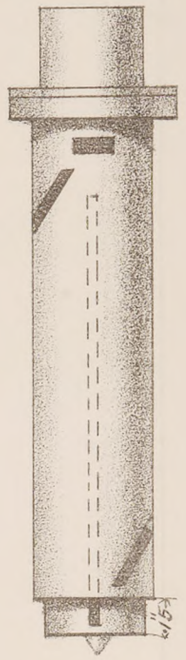


Concussion Action.

Comp.n Tube & Casing Tube set at Zero.

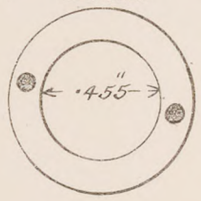


after concussion.

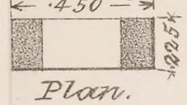


Jamming Collar. Section.

Plan

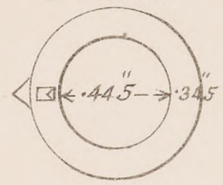


Top Plug



Plan.

Pointer



Elevation.

Detonator Box.

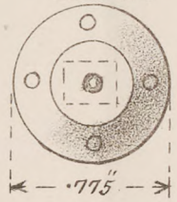
Plan.

Hammer.

Plan.

Bottom Plug Section.

Plan.



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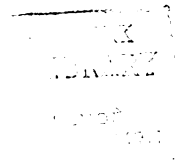

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RECENT EXPERIMENTS

WITH AN

11-INCH COMPOUND ARMOUR PLATE

AT

SHOEBURYNESS,

BY

MAJOR D. D. T. O'CALLAGHAN, R.A.

AN 11-inch compound, steel-faced, armour plate[1] has recently passed through such a severe ordeal, and has exhibited such curious phenomena in connection with the behaviour of steel when subjected to battering, that perhaps a short account of this battering may prove of general interest. The plate, manufactured by Messrs. Brown & Co., of Sheffield, measured 10 feet by 5½ feet by 11 inches, and was composed of about 7 inches of iron, faced by about 4 inches of steel, welded together by the process known as Ellis's patent.

This process may be roughly described by stating that a wrought-iron plate, rolled in the usual manner, is brought to a welding heat, and then covered with a layer of molten steel which is poured on to it and retained by a wall of wrought-iron surrounding the plate, after the manner of an open mould. When the mass is sufficiently cool, the double plate thus formed is rolled again, and its thickness considerably reduced. By this means a weld between the two metals of extra-ordinary tenacity is produced: in no instance has firing at the plate effected their separation.

In this particular instance the usual *modus operandi* was departed from, and the molten steel was poured between the wrought-iron backing and a face-plate about 1 inch thick of rolled steel. Both steels were precisely the same in composition, and contained the same amount of carbon, *i.e.*, 0·75 per cent.

[1] This is the same plate as the one referred to by Capt. Orde Browne in his Lecture on "Iron-clads," which appeared in last Number of "Proceedings."

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The plate was set up and backed as shown in Fig. 1, and practice was carried out against it with 9-inch R.M.L. gun, charge 50 lbs. pebble powder, at a range of 101⅔ yards, as follows:—

Round 1.—Service Palliser (studded) shell with gas-check. Weight as fired ... 260 lbs.
Striking velocity ... ... 1430 f.s.
Striking energy ... ... 4050 ft.-tons.

Shell struck 23 inches from top and 74 inches from proper right. Point remained in plate, the rest broke up small.

Depth of indent (measured after point was jarred out by next round), 5·55 inches. 7 radial cracks have developed, all unimportant, with the exception of one running upwards, which is 6½ inches deep at the top of the plate.

The bulge in rear is less than 1 inch high and exhibits three fine "hair-cracks" 0·3 inches long.

Round 2.—Service Palliser (studded) shell with gas-check. Weight as fired ... 260 lbs.
Striking velocity ... ... 1444 f.s.
Striking energy ... ... 4132 ft.-tons.

This shell struck 42 inches from top and 88½ inches from proper right,—21 inches from last round measuring from centre to centre. It also broke up small, leaving its point in the plate.

Depth of indent (measured after point was jarred out by next round), 6·65 inches. 5 very fine cracks were started, 2 of which were very small, and all were unimportant. The bulge in rear was less than 1 inch high.

Round 3.—Service Palliser (studded) shell with gas-check. Weight as fired ... 260 lbs.
Striking velocity ... ... 1432 f.s.
Striking energy ... ... 4050 ft.-tons.

Struck 50 inches from top, 57½ inches from proper left. Distance from last round, centre to centre, 28 inches, and from lower edge of plate 16 inches. Shell broke up as in previous rounds, point remaining in plate.

Depth of indent (measured after next round but one, had knocked out point), 6·9 inches. The cracks made by other rounds are slightly opened and one more very small one started. A piece of steel 2 feet 5 inches in length at its lower edge is flaked off between the damage and the bottom of the plate. The bulge in rear is 1·1 inch high, and has one central hair crack on its summit about 8 inches long.

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It will be seen that the above rounds form a triangle with sides of about 27 inches in length.

Round 4.—Messrs. Cammell's steel studded shell with gas-check. Weight as fired 279 lbs.
Striking velocity ... ... 1405 f.s.
Striking energy ... ... 3822 ft.-tons.

Struck 31 inches from top and 25 inches from proper left, and only 13 inches from Round 2, measuring from centre to centre; so that the damages of these two rounds merged. The shell produced no more effect than the chilled projectiles, and, like them, broke up, leaving its point in the plate.

The depth of indent, obtained by measuring to the point of cavity in the shell, was 6·75 inches. Some small cross cracks are started uniting old ones, but no new radial cracks are developed. The bulge in rear is only 0·68 inches high. There are several hair-cracks about ½ inch long on it.

Fig. 2 shows the appearance of the plate after successfully resisting the above four rounds, representing a total weight of 1059 lbs. of metal hurled against it with an aggregate striking energy of 14,869 foot-tons. The front is starred and cracked, and a piece of steel has come away in the vicinity of Round 3, but in rear the damage is practically *nil*. The shells have been handsomely beaten.

In the month of October last, the Authorities were desirous of testing two 12·5-in. (38-ton) studless steel shells, made by Messrs. Cammell & Co., and it was decided to fire them at this plate.

It was accordingly set up in front of an old 12-inch compound plate, 12 inches of oak backing intervening.

On examining the plate previous to this fresh series of experiments it was found that a star-shaped crack had developed near the side, (the proper right) away from the old damage. This is especially interesting, as it evinces a tendency of the steel to yield to the tension to which subsequent observation showed it had been subjected by the previous rounds from the 9-inch gun.

A point near this star-shaped crack was selected for the first round from the 38-ton gun, as it was believed to be the soundest part of the plate.

The details of this round, which we will call No. 5, were as follows:—

Range, 93 yards; charge, 160 lbs. P^2.
Weight of shell as fired (including gas-check) ... ... 840 lbs.
Striking velocity ... ... 1,425 f.s.
Striking energy ... ... 11,824 ft.-tons.

Struck 29½ inches from top and 41 inches from proper right (Fig. 3

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shows its position with reference to the old damage), making a circular hole 20 inches in diameter. A piece of the flattened-out head, and a curious cast of it (Fig. 4) punched out of the steel face remained in the hole among the *débris*. The body of the shell, which was apparently of inferior quality, opened out into the mushroom shape shown in Fig. 5, rebounded, and was found lying about two yards from the front of the plate, cracked in three places, and with the gas-check still adhering.

It was noted that after this round the plate was singularly free from the radial surface cracks usually developed in this class of armour. One, *a* (see Fig. 3), extending into the old damage, is right through the plate; *b* runs into the star-shaped crack before mentioned, *c* is insignificant, and *d*, running into the old damage, developed between the time the plate was examined after this round and the following morning.

In rear the bulge shown in Fig. 6 projected 12 inches (the thickness of the wood backing), and was prevented from going any further by being brought up by the plate in rear, which, however, shows no signs of injury. This bulge is held to the plate by a neck 16 inches across, and, when the *débris* was cleared away, there was space enough to admit a man's arm. The injury would, in all probability, have not been nearly as extensive had the plate been built up and supported as in a ship' side. The shell had, in fact, been kept out.

At the latter end of October, Colonel Inglis, R.E., wrote:—"There is really no room on the 11-inch plate for another reliable round from the 38-ton gun, still some information as to the quality of the remaining 12½-inch steel shell of Messrs. Cammell's make could no doubt be gained by firing it at this plate." In consequence of this, the now much-damaged and battered plate was again set up, strutted and backed as shown in sectional sketch No. 7, and the second shell fired at it, with the following result:—

Range, 93 yards; charge 160 lbs. P^2.

Weight of shell as fired (including gas-check	845 lbs.
Striking velocity	1,413 f.s.
Striking energy	11,695 ft.-tons.

The shell struck, as near as could be judged, about 18 inches from top, and 22 inches from proper left, and broke off the left top corner of the plate. (It should be remembered that this was almost on the spot where the 9-inch steel shell, Round 4, had struck previously). It made a hole, roughly speaking, circular, about 21 inches in diameter (Fig. 8), and remained, broken up in the hole. Nearly all the shell was collected and built up (Fig. 10). The back of the plate is shown in Fig. 11. The wood backing was wrecked and the 8-inch plate in rear (an old one) was broken into three pieces through old shot holes. It bore an impression of the mould separated from the back of the compound plate, extending over an area of about 12 inches circular, the maximum depth of which was about 1½ inch. Behind

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this the damage was *nil*. The face of the compound plate was now, however, wonderfully changed.

A large layer of steel was found to have come away from the front in the region of the indents made by the 9-inch projectiles, disclosing a very curious configuration of the steel round these depressions. Fig. 8 shows the crater-like form they exhibit, and Fig. 9 is a cross section through A B, showing their depth and the curved form of their sides.

This strange phenomenon perhaps throws some light on an appearance which has given rise to much speculation in former rounds fired at steel-faced armour plates.

It has always been observed that a wedge-shaped layer of steel is apparently separated radially round the indents, and, in early experiments, it was thought that a thin part of the steel face, the absolute uniformity of which cannot always be guaranteed, had been struck. The frequency of the appearance, however, negatived the theory, and the denuding of this plate seems to show what probably happened in other instances: the wedge-shaped layer of steel being, in fact, a portion of the surface or covering of the "craters," now removed.

It is wonderful to contemplate the intricate molecular movement which must have been going on under the apparently undisturbed surface of the plate, and which was merely indicated by the radial cracks which were developed, some at the time, and some considerably after the shot had struck: difficult, too, to realize the tremendous tension to which this surface was subjected, tightly stretched over the distorted metal beneath it. Yet, in spite of all this, the plate had still cohesive power left to withstand successfully the shock of the first 38-ton projectile.

It may be urged that this shell was of inferior quality, but when we take the state of the plate into consideration it must be confessed that it was a very remarkable performance.

Including the second 38-ton shell, which, had it struck a sound part, would probably have done little more harm than the first, the weight of metal fired at the plate now amounts to 2,744 lbs., striking with an aggregate energy of 38,388 foot-tons.

The actual causes which have given rise to the peculiar appearance of the surface laid bare by the flaking away of the crust, are rather obscure, and one or two authorities have bestowed a considerable amount of thought upon the subject.

The theory that is perhaps most worthy of credence is one which is really the outcome of several people's opinions, and may be briefly stated as follows:—

When a shot strikes and is arrested by a plate, the metal its point or head displaces must *go somewhere*. In a wrought-iron plate, it is (we believe) driven forward in a cone in front of the shot, the "bulge" at back presenting the well-known features of a pronounced swelling, which, if the point has nearly penetrated, is cleft by star-shaped

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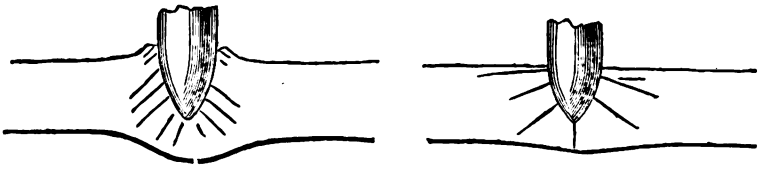
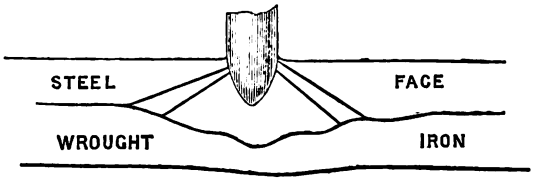
fissures. In addition to this, there is generally a high lip thrown up round the entrance of the hole.



Wrought-iron. Steel or steel-faced.

In a steel or steel-faced plate the appearances are very different. There is no lip, and the bulge in rear is scarcely perceptible, or, at all events, much less pronounced, hence it is evident that the metal round the point of impact is more impeded in its efforts to escape when displaced. Now it is clear that the displaced metal must be thrust away normally to the curvature of the head of the shot, and the direction taken by the molecules is represented by diverging rays in the figure at all angles between the vertical and horizontal. A bursting strain or thrust will be set up somewhere between these two limits, and along this line will there be a tendency on the part of the metal to separate, in other words, there will be a *line of cleavage*.

We should therefore be prepared to find a portion separated from the rest in the form of a cone bounded by straight lines. But it is not



so. The cone is, as we have seen, curved in section. How is this curvature to be accounted for?

When any metal is subjected to a crushing strain beyond its power of resistance, it evinces a tendency to buckle or bulge outwards—this is, I take it, the key to the rounded aspect of the exterior of what may be termed the "craters."

The steel displaced by the advancing point is crushed and yields *upwards*, or buckles into the cavity caused by its separation, or partial separation, from the rest of the plate; thus presenting the appearance of the rounded, indented cumulus, before described.

On examination of other broken compound plates in which portions of these *cumuli* are seen in section, it appears that, although it has never been before so favourably displayed, the same phenomenon has been invariably produced to a greater or less degree, and that therefore some law must exist which governs the motion of the particles in the disrupted metal.

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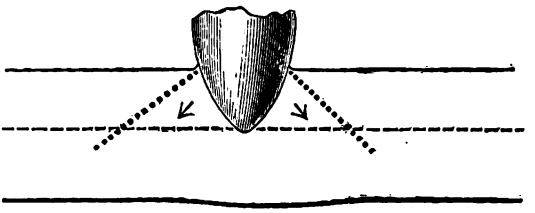
It remains for further experiments to throw more light on the subject, and to prove whether the theory above enunciated is worthy of adoption; at present it is only put forward as a conjecture fairly supported by facts.

Since writing this, I have received a letter from one of the greatest authorities on armour plates that we have, Colonel T. Inglis, R.E., in which the writer's views on the subject just discussed are set forth so clearly and vigourously that, with his kind permission, I quote them *in extenso*:—

"In the early stages of the entrance of the pointed head of a shot into a steel-faced plate, I imagine that the intense pressure of the shot is mainly borne by a cone, roughly described in this diagram.



"In fact, up to the stage shown, very little work can have been done upon the steel lying outside this cone. The pressure upon the material of the cone will be in the direction of the arrows, tending, of course, to compress it, while the adjacent steel outside the cone is not subjected to any great pressure. Hence, it would be natural to expect some separation of the cone from the rest of the steel. And it must be remembered that not only the steel of the cone under compression at this stage, but its base is resting all the time against a bed of soft wrought-iron, which must yield more or less under the pressure and so facilitate the separation of the steel.

"The reason for the cone not being a true figure, but more often, I believe, bounded by curved lines is, I have no doubt, due to the form of the head of the shot—and probably we could, by varying the form of head between a blunt and very sharp cone, alter the form of cone in the armour almost at will.

"Of course, the steel face outside the cone becomes more or less compressed in later stages of the entrance of the shot, but by that time the main separation has taken place, and although the pressure in those parts is borne more entirely by the steel and conveyed in a less measure to the wrought-iron of the armour, yet, if we could more fully examine the effects produced in several of these rounds, I should expect to find the commencement of other cones beside the main one.

"In a soft, plastic material the action must obviously be very different, and hence the reason for these cones of separation not having been observed before the introduction of steel-faced armour."

* * * * * *

It may be thought by many readers that a purely technical detail has

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been talked about and threshed out, almost *ad nauseam*, but it is not for this reason that I refrain from making any remarks upon Colonel Inglis's able letter. It is rather because I feel that I could add nothing to it, and also that it would be presumptuous on my part to attempt to do so.

To a few the subject may commend itself as one not only interesting from its surroundings, but perhaps doubly interesting by virtue of its obscurity, and they will, I trust, forgive, what must have seemed to some, a laboured and tedious description.

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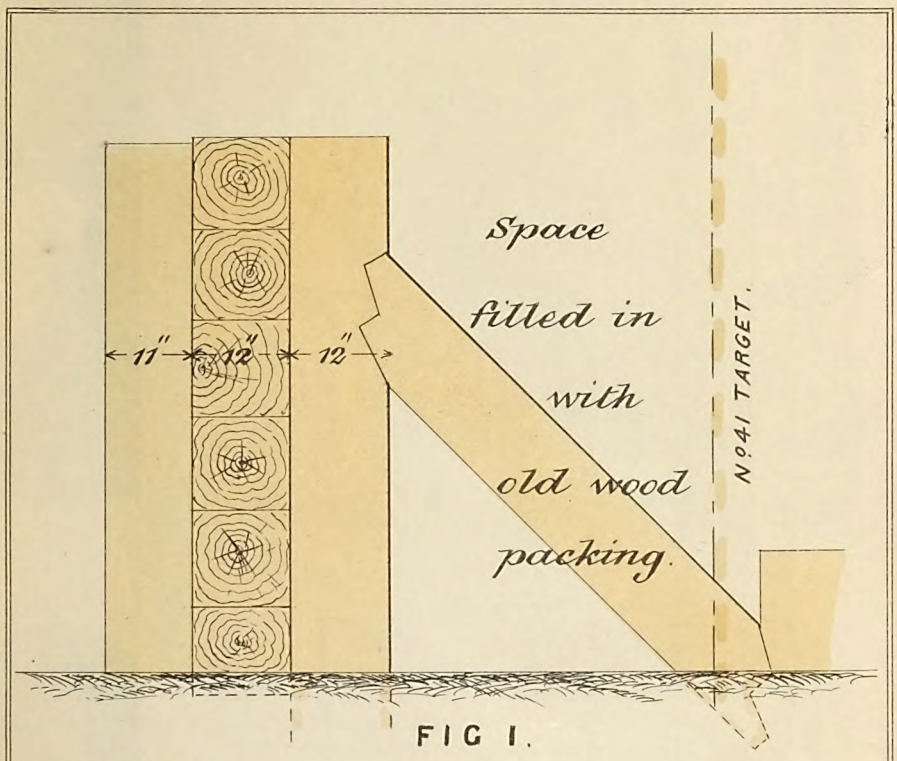

FIG 1.

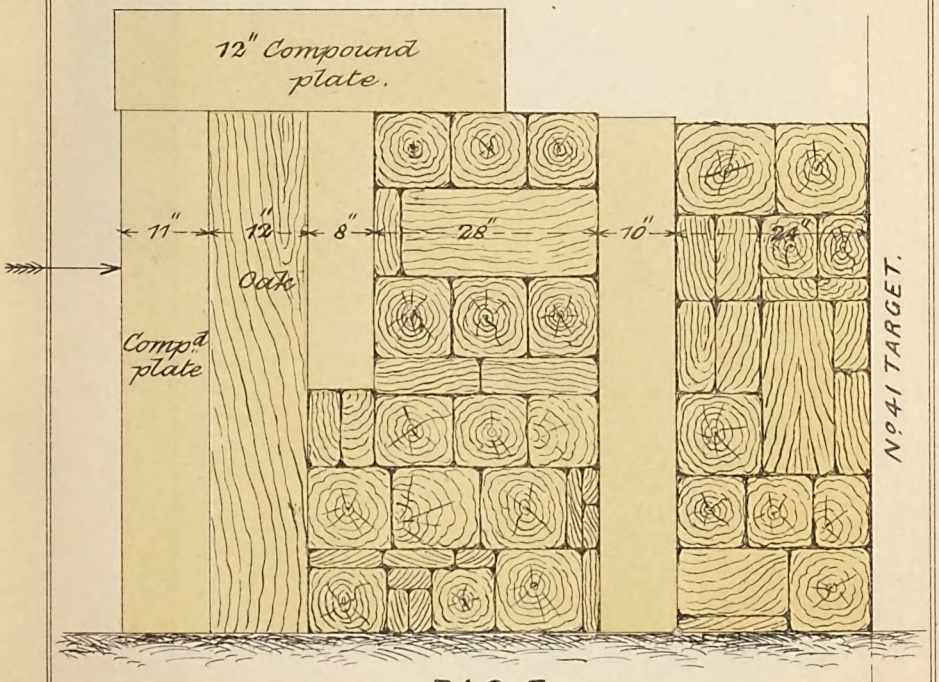

FIG 7.

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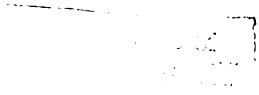

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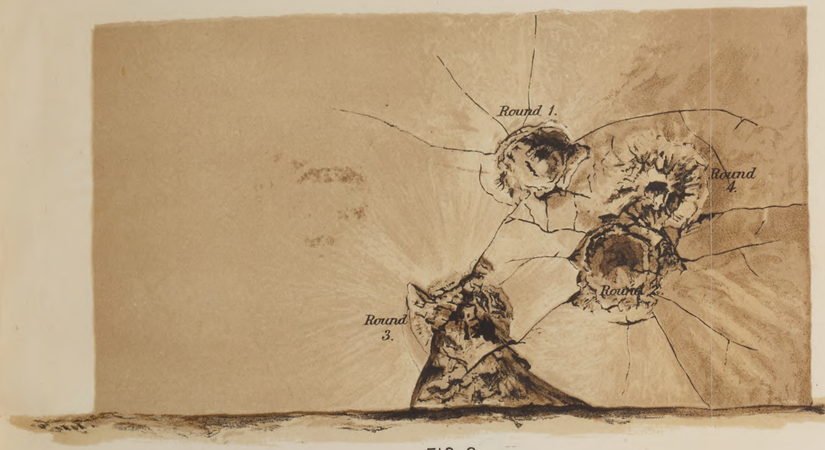

FIG 2.

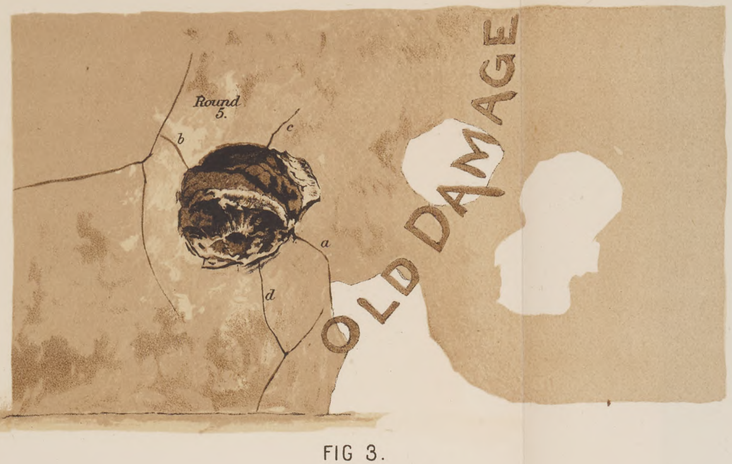

FIG 3.

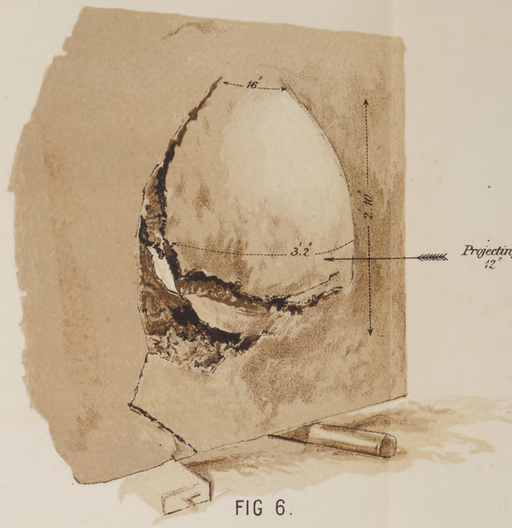

FIG 6.

FIG 10.

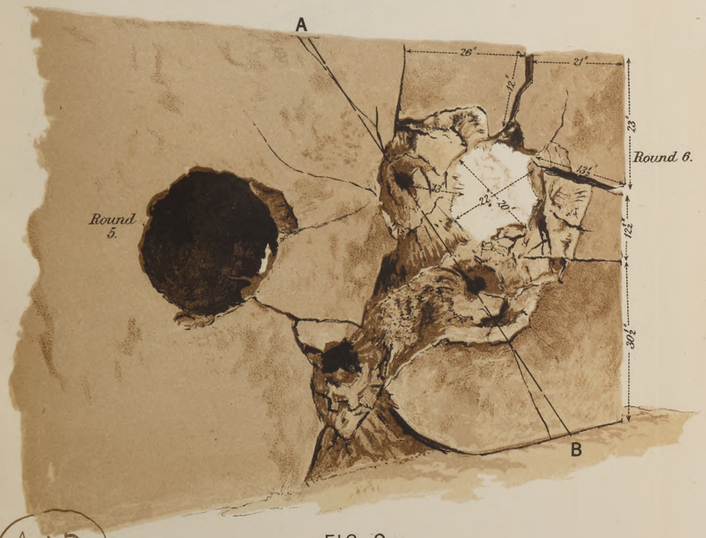

FIG 8.

FIG 4.

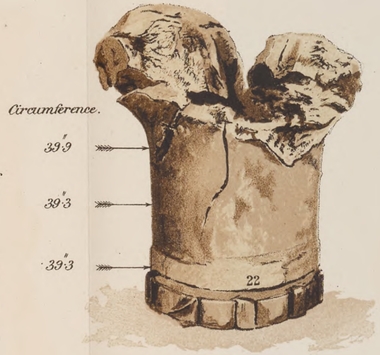

FIG 5.

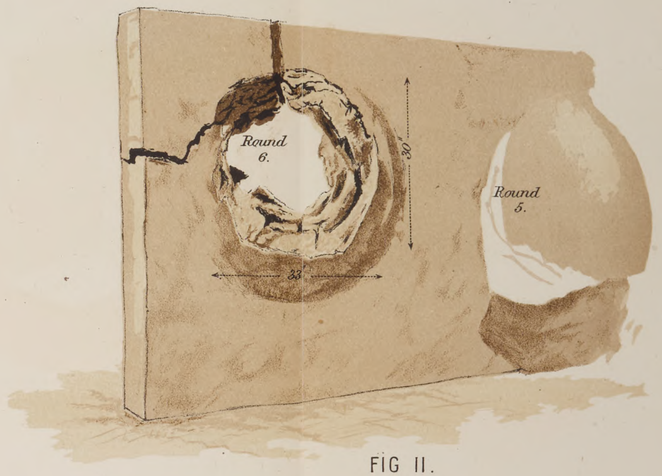

FIG 11.

FIG 9.

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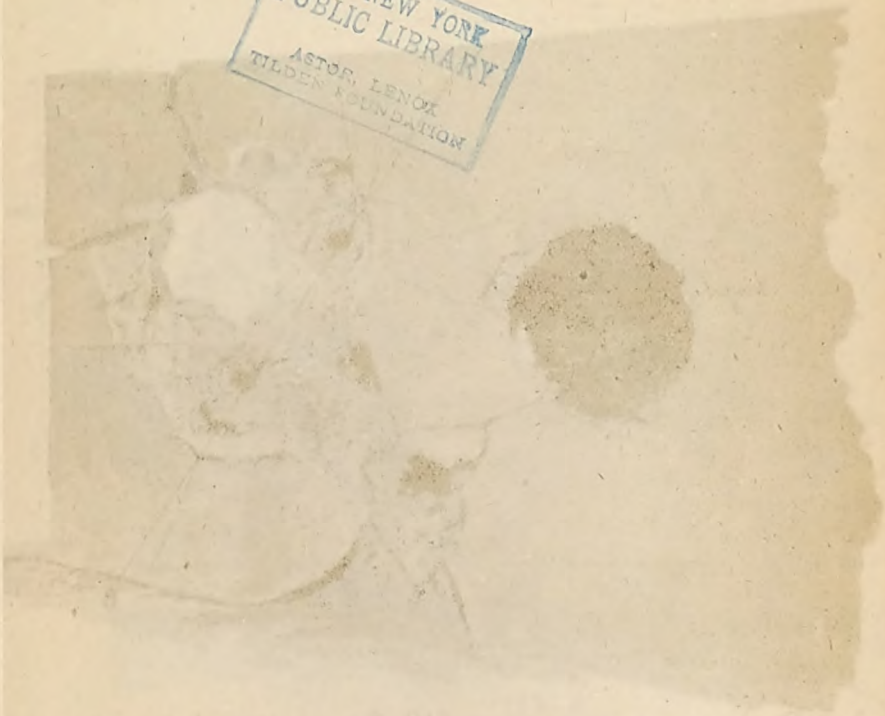

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RAILWAYS IN WAR.

A REVIEW;

BY

LIEUTENANT J. M. GRIERSON, R.A.

"Die Kriegführung unter Benützung der Eisenbahnen und der Kampf um Eisenbahnen"; von H. L. W. KGL. PR. HAUPTMANN.

"RAILWAYS are of such paramount importance in war, and their proper use is so difficult and so liable to produce confusion, that full and complete instructions are requisite;"—so runs paragraph 26 of the "Regulations for the Organization of the Line of Communications of an Army in the Field."[1] It is precisely these "full and complete instructions" that are contained in the excellent though somewhat bulky and verbose volume whose title stands above, and whose second edition (the first was issued in 1868) has just been published by "A German Staff Officer." The conditions, the amount of traffic, and the construction of German Railways are so totally different from those of our own lines, that a great deal of the detail matter contained in the book is inapplicable to English railroads. Still, the principles laid down are so clearly explained, the advantages of the use of Railways in war are so well brought to light by examples from the recent campaigns, and the conclusions drawn from those examples are so strictly logical, that we do not hesitate to express a hope that the book in its entirety may soon be translated into English, when it certainly will take its place as a standard text book in our military literature.

When Railways first made their appearance, their advantages in a military point of view were considered doubtful; but their pre-eminent value having been demonstrated by recent wars, every Continental Power now treats them as factors of the first importance in its offensive or defensive strength, reckons with them in all stages of operations, studies their nature and management, and takes measures to ensure

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[1] Issued with Army Circulars, 1st June, 1878.

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their extreme development and perfect co-operation in war. Their importance cannot be better shown than by the fact that within the last 15 years all European nations, England excepted, have added a fifth branch of the service to their armies—Railway Troops.

The first condition for the successful management of Railways in war is a careful organization in times of peace. In Germany this condition is fulfilled by the appointment of a certain number of "Line Commissions," which are subordinated to the Railway Department of the General Staff. The object of those Commissions is to study the resources of their own line, to draw out Time-Tables, and in general to make arrangements so that in war the maximum of work may be got out of the line. The General Staff would determine what particular Corps were to use the line in case of a concentration of the Army, while the Commissions work out the details of this movement. Thus the general management is centralized. The detail management is decentralized. At the head of each Commission is a military Officer, who is assisted by a number of technical men. These functions would in our service be fulfilled by the Railway Inspectors of the Board of Trade, working under the Quartermaster-General, while to each line would be appointed a Railway Staff Officer, to act as military assistant to the traffic manager. The great difficulty, in our own country as in Germany, which has to be contended with is the number of Companies owning the lines, who frequently have conflicting interests which are difficult to reconcile; but we trust that the powers which the Secretary of State for War has over all railways by the Army Regulation Act would be more than sufficient to ensure the harmonious working of our lines in case of national emergency.

The uses of Railways for military purposes may be classed under three great heads:—The Mobilization of the Army; the Concentration of the Army; and the Supply, &c., of the Army during operations, which latter also includes strategic movements of bodies of Troops by rail within the theatre of war.

I. The essential of a quick mobilization is that the *cadres* shall be stationed in the territory from which they draw their reserve men, and that their stores of clothing, arms, and equipment shall be at their immediate disposal, and not concentrated in vast central magazines. With us the former condition is not fulfilled, and Railways would doubtless play a prominent part in a mobilization of British Troops. Their use, however, at so early a stage of the operations is to be deprecated, as the rolling stock is thus kept in constant motion, and the Railway authorities are unable to collect the necessary *matériel* at the main stations for the important operation of concentration. Therefore all parties of reserve men, &c., who can reach their Corps in good time by route march should be sent by road. During this period the Railway staff will have to take their measures for collecting rolling stock at the principal entraining stations, for establishing extra platforms and loading ramps, for fitting up the stations (at which halts are to be made for feeding the Troops and horses) with cooking places, watering places, latrines, &c., and for obtaining from lines, not in the main

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route, the necessary complement of additional *personnel* required by the increased amount of traffic.

II. Opinions differ as to the advantages of concentrating all the Troops by rail on the threatened point of the frontier; the opponents of the system, who are decidedly in the minority, alleging that what is lost in time is gained by the better condition of the troops, who are hardened by long marches. But the important advantage of being able to take the offensive by an earlier concentration of Troops than the enemy is sufficient to outweigh all those considerations, and the marching power of Troops, previously carefully trained, will not be spoiled by a few days in a Railway carriage.[1] Besides, Troops do not alight on a platform and forthwith proceed into action. The best system of Railways must always leave a certain number of marches in the zone of concentration to be done; and by using the Railway the Troops are brought up intact, the transport columns, &c., arrive with them, and one's own country is spared the inevitable hardships produced by the passage of a large body of Troops. The enormous advantage Prussia gained by her Railways in 1870 was illustrated in the war of 1877. The second battle of Plevna brought operations to a standstill till the arrival of Russian reinforcements. Within a month the Guard Corps was concentrated by rail near Plevna: without Railways this operation would have taken nearly 3½ months. The Troops quartered nearest the frontier threatened should concentrate by march route, the remainder should be moved by rail. A most important point in the concentration of masses of Troops is the choice of a detraining station. If one thinks of the enormous time it takes to load a trainful of Cavalry compared with one of Infantry, it is evident that, if a regular succession of trains is to be maintained, several trains must be loaded or unloaded simultaneously. For this, several platforms are necessary. Besides, a detraining (or entraining) Station must have a yard into which trains can be shunted till their time to return or start arrives, engine houses, workshops, facilities for watering and coaling engines, facilities for shunting, and, above all, clear approaches to the station, and space outside for forming up Troops. A short précis of the concentration of the German Armies in 1870 will serve to explain this important operation better than all general principles. The mobilization of the Troops was completed in 8 or 10 days, the 16th July being the first day of mobilization; and 8 days later the concentration began, the regular passenger traffic having been suspended a few days before. So perfect were the arrangements made during peace, that on the 17th July most Army Corps had already received the complete Time-Tables for their move towards the French frontier. In these even the transport of the reserves to their Regiments (in the few cases in which those latter were not stationed in their own districts) was laid down. The entire Railway System of

[1] [In the case of ill-trained Troops, there is much to be said on the other side of the question. See some excellent remarks on the transport by rail of Bourbaki's raw Troops in "*Militärische Gedanken und Betruchtungen über 1870-71*," pp. 209, *et seq.*; *Mainz*, 1871.—*H. W. L. H.*]

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Germany was divided into 13 lines; 10 (A to K) for North, 3 (I. to III.) for South Germany, as shown on the map. Of the former, the lines B and D were available for light traffic only, and were used to transport one Army Corps each; those lettered A, C, E and F each transported two or more, and the remainder drained the more remote provinces, whose troops then proceeded by one of the above four lines.

The distribution by lines was as follows:—

Line.	
A.	3rd (Brandenburg), 10th (Hanover), ⅛ of 1st (East Prussia), ½ of 2nd (Pomerania) Army Corps. Detraining station, Neuenkirchen.
B.	18th Division (9th Schleswig A. C.) Detraining station, Mosbach.
C.	Guards, 4th (Magdeburg), 11th (Hessian), ⅛ of 1st and ½ of 2nd Army Corps. Detraining station, Homburg.
D.	12th (Saxon) Army Corps. Detraining station, Castel.
E.	5th (Posen), 6th (Silesian) Army Corps. Detraining station, Landau.
F.	7th (Westphalian) Army Corps. Detraining station, Call; thence route march.
G.	1st Army Corps.
H.	2nd do.
I.	9th do.
K.	6th do.
I.	2nd Bavarian Corps. Detraining station, Wieslach.
II.	1st do. do. do.
III.	Wurtemberg Division. Detraining station, Carlsruhe.

The 8th (Rhineland) Army Corps, and the Baden and Hesse-Darmstadt (25th) Divisions were concentrated by route march. Thus the 1st Army was concentrated, by route march and line F, about Saarbrücken; the 2nd, by lines A, B, C and D, about Neuenkirchen; and the 3rd, by lines E, I., II. and III., between Landau and Carlsruhe. The full plan was not, however, carried out, as, owing to the threatening attitude of the French army, Neuenkirchen and Homburg were thought too exposed, and Bingen and Mannheim were made the detraining stations for lines A and C, respectively, for which they were neither suited nor prepared. Thus, gradually, a block of empty trains accumulated there, which, although it had no perceptible influence on the concentration, produced great difficulties afterwards in the matter of forwarding supplies. The transport of the Troops was calculated on the basis that on a double line of rails 12 to 18 trains could be despatched daily, on a single line 8 to 12. By the 31st July, the Guard, 3rd, 4th, 7th, 8th, 11th and 12th Army Corps, the Wurtemberg, Baden, 25th, and 18th Divisions, and most of the 5th, 10th, and 1st

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and 2nd Bavarian Corps were concentrated in their respective zones, and in three days more were ready to march. By the 4th August, the 1st, 2nd, and 6th Corps were complete. Thus 10 days had sufficed to concentrate 334,000 men, with 100,000 horses and the necessary carriages.

Turning to the other side of the frontier, a very different picture is presented. The French plan of mobilization was to despatch the Regiments at once on peace strength to the points of concentration of their respective Army Corps, and to send their reserves, equipment, and stores after them. The vast evils of over-centralization then became apparent. All articles of camp equipment were stored at Paris and Versailles, all wagons for supply and ammunition columns, &c., at Vernon and Chateauroux; and France presented the spectacle of Railways clogged and cumbered with endless trains of wagons, reserve men, stores, &c., &c., all drifting towards the eastern frontier, but none knowing their precise destination, nor what Regiments they belonged to. At Head-quarters, even, it was not known where particular Regiments were stationed, and their reserve men remained without orders. A telegram from the General Commanding at Marseilles to the War Ministry is on record which runs—"9000 reserve men here. Don't know what to do with them. To get rid of them I shall ship them all for Algiers!" All praise, however, is due to the French Railway authorities, by whose exertions a much higher rate of traffic was maintained than on the German lines; 24 trains a day being the average on double, 18 on single lines. They had to make all arrangements, because the French Staff, unlike the Germans, concerned themselves with no detail arrangements, but merely sent to the Railways a requisition to transport so many men, horses, and carriages from so-and-so to so-and-so. The general result was that by the 4th August, when the Germans took the offensive, some of the French Army Corps (notably the 6th) were not yet fully concentrated, and none were up to the war strength or completely provided with those stores and columns which are indispensable for an Army operating in the open field.

It is not easy to apply the above examples to our own country, because we are not aware what measures would be taken to ensure the prompt mobilization and concentration of our forces. Fortunately for us the silver streak of sea is a tolerably good safeguard against a surprise, but we are far from believing it to be an invulnerable one. Our Regiments are not always stationed in their recruiting districts, and the Railways would have to be used for the transport of reserves to their Regiments. The simplest plan seemingly would be to have the transport wagons, &c., necessary for a Battalion, &c., stored at such places as are usually the Head-quarters of a Battalion in peace, while the necessary clothing, arms and equipment for the reserves required to bring the Battalions up to war strength might be stored at the Regimental District Head-quarters. The reserves would then be completely equipped there and sent by rail to their Battalions. The system of Territorial Regiments has immensely facilitated mobilization, and at a future period we shall not see, as in 1878, the Army and Militia

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Reserves joining their Battalions with a cap, serge, and trousers, but without boots, great coats, kits, and rifles until Woolwich, Pimlico, and the Tower had time to disgorge their innumerable stores.

III. It is when operations have commenced that the Railways enter on their third stage of activity, that of supplying the Army. The great object in this case is to endeavour to make the Railway communication keep pace with the advance of the Troops, and the more lines that can be made available for this purpose the better. Seldom however, unless a campaign is of long duration, will an Army operating in an enemy's country be able to avail itself of more than one main line. Thus at first in the war of 1870, the 1st and 2nd Armies were able to use the line Saarbrück-Metz (Courcelles), the 3rd Army the line Weissenburg-Vendenheim-Nancy. The former line, however, could not supply the wants of the troops before Metz, and the line Nancy-Frouard-Pont à Mousson had also to be utilised by them, thus mixing up their stores with those of the 3rd Army. The failure of the Saarbrück line was caused by the block in the concentration zone, which we have above-mentioned, and it was only after immense exertions that this was cleared away, and the transfer stations, to which we shall refer later, properly organized. As the 3rd Army advanced towards Paris, the difficulties of Railway communication increased; to lighten the burden on the Weissenburg-Nancy line, Saarbrück was brought into communication with Nancy by means of a field Railway from Remilly to Pont à Mousson, over 20 miles long, which was built between the 14th August and 23rd September, but which gave very small results, only 4 trains a day of 10 to 12 carriages being sent by it. Metz capitulated on the 29th October, and on the 30th the whole line Saarbrück-Metz-Frouard was in working order. To open communication between Paris and Nancy the capture of Toul, which blocked the line, was necessary. This took place on the 23rd September, and on the 28th the first train steamed into Nanteuil, which was the nearest station to Paris available. An attempt to construct a field Railway circumventing Toul failed through difficulties of construction. Nanteuil was a small station, quite unfitted for the terminus of a line which had to supply 200,000 men; and to relieve it, stores, &c., for the Meuse Army (holding the northern sector of the investing circle) had to be unloaded at Chateau Thierry, and thence sent by road. Later on, after several bridges had been restored, Lagny was made the terminus for the main line. Here the central supply magazine, and the Head-quarters of the field hospital, postal and telegraph services, were established. At Vaires, 5 kilomètres further from Paris, the Central Artillery Depôt was placed, and at Esbly, 3 kilomètres eastward, prisoners were entrained, and reinforcements detrained. Thus by careful organization of all services, and by distributing the termini over several small stations in default of one large one, the proper and regular supply of the Army was ensured. This was actually the only line which the Germans succeeded in making practically available, for the line Paris (La fère Soissons)-Rheims-Mezières-Thionville-Metz was only opened on the 1st January, 1871, after the capture

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of Laon, La fère, Soissons, Thionville, Montmèdy and Mezières. The important line Hagenau-Bening was blocked all through the campaign by the little fortress of Bitsch. From the above it will be seen how long it takes to obtain possession of a line blocked by a number of small fortresses. To make Railways speedily available those fortresses must be captured. It is unnecessary to add that an Army must be provided with a body of good Railway Troops, able not only to construct and repair lines *but also to work them;* and one central directory is required for all the Railways of the theatre of war, assisted by Commandants for each line.

Great are the services that can be rendered by Railways, both in the defence and in the attack of fortresses. Previous to an investment provisions and stores can be brought in, and obsolete stores, which are occasionally treasured in fortified places (abroad, of course), can be removed.[1] Thus Paris was provisioned for the siege in 35 days, 14,982 wagon loads having been brought in in that time. The French neglected to remove enormous stores of clothing, equipment, &c., from Metz, and those all fell into the hands of the Germans. For the attack of fortresses, the co-operation of the Railways is indispensable. The *matériel* of a Siege Train is so heavy that its transport by road quickly renders the road impassable. The first example of a Railway used to bring up the Siege Train is our own Railway from Balaclava to Sebastopol, which though constructed late in the siege rendered inestimable services. Before Paris, 160 heavy guns, with their ammunition, were brought up to Nanteuil from the base in 10 days, but their further transport to Villaconblay (50 miles) required 8 days, so bad were the roads and so insufficient the teams employed. In future sieges, Railways will probably be constructed to connect the terminal station with the Artillery Park, and those may even be prolonged to the trenches. Good roads will facilitate the laying of such lines as they form a good foundation. On the services rendered by Railways in carrying wounded to the rear, in bringing up ammunition to replace that expended in action, and in relieving the army of prisoners who have to be rationed the same as one's own Troops, we need not dwell; and shall pass at once to the strategic uses of Railways in the theatre of war.

As a general rule, the defensive gains more from the use of Railways than the offensive. An Army in the former case would have the whole resources of its country behind it, and could make use of them to the uttermost, while the attacking force will seldom be able to reap much benefit from the Railways of the occupied country. During the campaign in France, the Germans made little use of the Railways for strategic purposes, but when they did it was with great effect. Thus for the Battle on the Hallue (23rd and 24th December) 6 Battalions of the 1st Army Corps were despatched by rail from Rouen to Amiens to

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[1] [For instance, an excellent supply of *stone* shot was discovered in the Magazines of Strasbourg, when that fortress fell into the hands of the Germans in 1871.—*H.W.L.H.*]

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support General von Göben, and the battle was won; 4 of them returned on the 28th and 29th to Rouen. Again when Faidherbe took the offensive after the Battle of Bapaume, 12 Battalions and 5 Batteries were sent by rail from Rouen to Amiens between 7th and 18th January, which enabled the Army of the North to hold its position. On the French side, great use was made of the lines of rail for strategic purposes. Thus a Division of the 7th Corps was transported by rail from Mühlhausen to Wörth in 24 hours, to take part in the battle at the latter place: had the Troops moved by road, 7 or 8 days would have been necessary. Canrobert's Corps was conveyed from Châlons to Metz; Vinoy's from Paris to Mezières and back after the battle of Sedan; and Bourbaki's Army was moved eastward to threaten the German communications by rail. All those movements were strategically correct, although their detail arrangements were essentially vicious. In Bourbaki's movement the errors come most into prominence. The stations chosen for entraining and detraining were unsuited for the purpose; the tactical units were broken up or unaccompanied by their columns, and no arrangements were made for the return of empty rolling stock. Besides, the Troops were ill-provided with transport, and recourse was had to "Railway Provision Columns," that is, trains filled with supplies, which remained on the lines till required. An enormous block took place in consequence. When the Army was forced to retreat the line could not be cleared, and not being able to withdraw by rail, and being inferior in marching power to Manteuffel's Army, Bourbaki's Troops had to withdraw across the Swiss frontier.

The most difficult and delicate operation that can be performed by rail is the withdrawing of a beaten Army before a victorious enemy. By this means it can gain time to re-organize and recover its *morale*; the difficulties of feeding a large body of Troops on a long retreat are avoided; and the enemy loses touch. The main difficulties in the way are the gathering of the necessary rolling stock, the impossibility of determining the precise entraining stations, and the extra wear and tear on the Railway *personnel*, caused by the enormously increased traffic. To effect a retreat thus as large a number of lines as possible must be made available, and an entraining zone, if possible, fixed; the number of Troops moved by each line must be proportionate to the power of the line, dispositions must be made for the removal of the sick and slightly wounded—the severely wounded being left behind under the Red Cross; a position must be taken up to protect the entraining zone, and measures taken to prevent the lines from being cut by parties of the enemy's Cavalry. Rough Time-Tables must be made out; the Infantry of the Rear Guard embarking first, next the Artillery, then the Cavalry, the Railway Troops following last and destroying the lines. The above principles have been deduced from MacMahon's retreat after Wörth, and the retreat of the Austrians to the Danube in 1866.

Railways have also been used to transfer Armies from one theatre of war to another as in 1866, when 2½ Corps of the Austrian Army of the South were transported to Vienna on two lines (one partly by route march) in 18 days, an operation which without Railways would have taken

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45 days. Only in very rare cases will Railways be enabled to afford tactical support to Troops. During the Battle of Spicheren, however, orders were received in Neuenkirchen at 1.30 p.m., to despatch the 12th Grenadiers to Saarbrück by rail, and at 3.30 p.m. the 1st Battalion was in action, the other two following at intervals of half-an-hour. In the defence of fortified camps a circular Railway would doubtless afford valuable tactical support, and during the American War and the Siege of Paris, guns in armour-plated wagons, moving along a line of rails, were used with some effect.

Before proceeding to the consideration of the organization of Railway transport, we may mention the important services which might be rendered by Railways for coast defence. The most favourable trace would be a Railway parallel to the coast line and a sufficient distance inland to be safe, with branches to the principal points on the coast and the interior. Watch towers and signal stations would be established along the coast; buoys, &c., would be removed, a coast guard would be organized, and strand Batteries constructed in situations favourable to a landing. Behind these the Troops would be concentrated in bodies of all Arms at the Railway junctions, whence they could be removed tothe threatened point. Time-Tables would have to be made out for every contingency, and rolling stock always held ready. Trains should be provided with means of detraining their loads outside stations, and the Advanced Guard trains should be filled with all three Arms.

In consequence of the experience gained in 1870–1, new regulations for Railways were issued in Germany in 1872. The lines of communications of an Army in the field are placed under an Inspector General of the Lines of Communications, and directly subordinate to him are the Chiefs of the field Railway, road, medical, telegraph, and postal services. The Chief of the field Railways has a technical *personnel* at his disposal, and for each line a Director (under whom is placed a detachment of Railway Troops) is appointed, who fulfils the same duties as the Line Commissions on the home lines, and arranges besides for the construction and repair of his line. Each Army Corps has in its own district a "Collecting Station," at which all Troops, stores, &c., for the Army Corps are collected. These (under orders of the Line Commissions) are forwarded hence to the "Main Collecting Station," and are stored there; or Troops are gathered till trains can be made up to take them on to the front. For this purpose a large roomy station is required, with numerous platforms, goods yards, train yards, engine houses and store sheds. In front of this is the "Transfer Station," near the frontier, where the jurisdiction of the Line Commission ends, and that of the Military Railway Direction begins. At the Main Collecting Station companies of workmen are formed for loading and unloading trains, and from it supplies are sent on to the Magazines on the Line of Communication. A few trains should always be kept loaded with provisions in it to provide for unforeseen contingencies. The Main Collecting Station is the seat of the Line Commission during military operations, and each station has a Military Commandant to ensure the punctual departure

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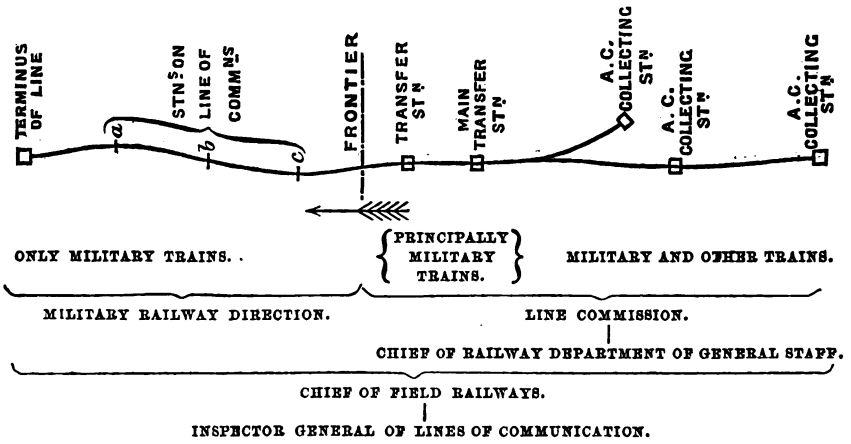
of trains, and the keeping of good order in the station. The subjoined sketch shows the general organization during operations:—



Our own system of military Railways differs but in name from the above. In operations in a foreign country a seaport would be chosen as the base of operations which would correspond to the Main Collecting Station, the Transfer Station being omitted possibly.

The construction, the number of the *personnel*, and the amount of ordinary traffic on a line are the factors which determine how far it can be made available for military purposes, and it is of the utmost importance that all of the Railways of a country should be of an uniform gauge, so that the rolling stock of one may be used to reinforce that of another. With us, as in Germany and the Continent in general, with the exception of Russia, the gauge adopted is 4 ft. 8½ ins. (1·435 mètres), in Russia it is 5 ft. (1·524 mètres). Thus, in a campaign in Germany, the Russians would find it difficult to utilize their own rolling stock, while Germany would find little difficulty in laying down a third rail on the Russian lines to suit their smaller gauge. War traffic entails increased exertions on the part of the Railway employés, but there are a large number of them which are not required in war. Thus, station officials can be supplemented by men from the offices, engine drivers by experienced stokers, and the number of guards, &c., could well be reduced, while porters could be taken from the workmen and navvies on the line. The trace of a line influences military transport by the sharpness of its curves and the steepness of the slopes, both of which tend to diminish the speed of the trains, and steep slopes entail a corresponding increase in the number of break vans required, thus lengthening the train. On double lines of rail, empty trains can return by the up line, and the interval of time separating two consecutive trains must only be equal to the interval between the two farthest apart stations on the line. On a single line, on the contrary, the interval between trains must be equal to double the distance between the two farthest apart points at which trains can pass one another, but single lines can be used to the same extent as double ones,

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if a different line is available by which empty trains can return. Of the conditions determining how far stations may be utilized we have spoken above. The Germans lay down that an engine travelling at 14 miles (22½ kilomètres) per hour requires watering every 9 to 14 miles, and that its tender holds fuel enough (60 to 70 cwt.) to last 15 hours. Those conditions must be remembered in arranging for halts. With our smaller trains and higher rate of speed, an engine consumes about 100 cubic feet of water and 8 cwt. of coal per hour, but in operations abroad, we should probably have to work on foreign data. They consider 500 yards of platform necessary for loading a military train simultaneously. For entraining gun-carriages, &c., ramps (such as exist at Farnborough Station, Aldershot) which permit of the carriages being run along the whole length of the train from the end are best. To effect this, the ends of the trucks are let down and form a continuous roadway. Horses and men are best loaded from the side.

With regard to the rate of movement of trains, a low rate per mile allows of a heavy train. If a high rate be required, the trains must be shortened, and more of them run, and then either the total period of transport is increased or the interval between the trains must be diminished. In both of the latter cases, the work of the Railway employés is made much more severe than with slow trains, and accidents and delays are more likely to happen. Our neighbours have therefore adopted the principle of heavy trains moving at a slow rate. The rate for military trains is 14 miles (22½ kilomètres) per hour, and the maximum strength of a train is laid down at 120 axles. This permits, allowing 16 men per axle, of 1 Battalion (1000 men), 1 Squadron (150 horses), or 1 Battery being conveyed in a train. Including Ammunition Columns, &c., a German Army Corps requires about 100 trains. With us, the opposite principle holds, due no doubt to the greater amount of traffic on our lines and the greater experience of our Railway employés in managing heavy traffic. A Battalion requires 2 trains, a Squadron (120 horses) 1 train, a Battery 2 trains, and an Army Corps on the war footing 189 trains. In operations abroad, however, where existing foreign lines were utilized, it is a doubtful matter whether our organization would not have to give place to that adopted by the Germans.

Finally, we have to consider the system of making out the military Time-Table and the Concentration-Table. The former is made out for 24 hours of traffic, and is started by fixing the hour of arrival at the *detraining station* of the first train, and working backwards. To the total time required for the journey, which includes short halts for watering the engine, must be added one hour in every eight or nine for feeding the Troops, and half-an-hour every four hours or so for halts for drinking and other necessary purposes, besides fifteen minutes for each point where the engine requires to be reversed or the train divided. The total time determines the hour of departure of the train from the entraining station. The interval between trains is calculated as above. It is found best to divide the day into reliefs of six hours, and have no military trains arriving in one of the reliefs, in order to allow for coal trains, special trains, &c., passing along the line. The

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Time-Tables are then made out stating the number of each train, the name and strength of the Corps it contains, and the date and hour of its arrival or departure at the entraining, detraining and halting stations. The Table of Concentration is then made out for each Army Corps, showing the date on which each unit is ready to march, and the dates of its departure from its garrison and arrival at the detraining station.

The transport is carried out on the following principles:—Combatant units will take precedence of non-combatant, tactical units must be kept together, Divisional Cavalry is transported before the Infantry of the Division, the Divisional Artillery follows the 1st Infantry Brigade, and is followed by the Pioneers, Bridge Train, and Ambulance. Staffs go in the same train with the first unit of their command, the Corps Artillery is placed between the two Infantry Divisions, the Bakery Train is the first of the auxiliary services forwarded, and four trains full of provisions move with each Army Corps to provide for first wants in the zone of concentration, but wagons with provisions should never be attached to Troop Trains, on account of the time they take in unloading.

Judging from the specimen tables, issued by authority, the same general arrangement would hold good with us, the Cavalry Brigade of the Army Corps being forwarded first, and Divisional Artillery following its Division. In those tables, the average speed of the trains is taken at 25 miles an hour, the greatest number of carriages in a train being 34 (68 axles).

In a second paper we propose to consider the organization of Railway Troops, and the attack and defence of Railways.

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MAP of the German Lines of Railway used for the transport of troops in the war of 1870.

North German Lines.
- Line A
- B
- C
- D
- E
- F
- G
- H
- J
- K

South German Lines
- Line I
- II
- III

Remarks

The Stations at which halts are made for feeding the troops are underlined singly; the entraining Stations doubly.
The Stations of the Line Commissions are marked L.K.

Flensburg
Kiel
Neustadt
Neumünster
Rostock
Stralsund
Wismar
Lübeck
Altona (L.K.)
Hamburg
Harburg
Hagenow
Pasewalk
Stettin
Colberg
Stolp
Danzig
Königsberg
Dirschau
Bromberg
Schneidemühl
Thorn
Angermünde
Berlin (L.K.) (L.K.)
Güstrin
Frankfurt
Posen
Guben
Hansdorf
Kohlfurt
Liegnitz
Breslau
Görlitz
Lauban
Neisse
Frankenstein
Odersburg
Dresden
Zittau
Leipzig (L.K.)
Halle
Magdeburg
Braunschweig
Hannover (L.K.)
Nordstemmen
Rheine
Bünde
Bersum
Kriensen (L.K.)
Holberstadt
Paderborn
Dortmund
Hamm
Unna
Hagen
Letmathe
Neuss
Düsseldorf (L.K.)
Cöln
Düren
Call
Göttingen
Nordhausen
Cassel
Guntershausen (L.K.)
Erfurt (L.K.)
Bebra
Fulda
Wetzlar
Giessen
Coblenz
Mosback
Bingerbrück
Mainz
Castel
Frankfurt
Aschaffenburg
Darmstadt
Lichtenfels
Heidingsfeld
Nürnberg (L.K.)
Schwandorf
Regensburg
Geiselhöring
Passau
Kaiserslautern
Neunkirchen
Homburg
Neustadt
Landau
Neckargemünd
Mosbach
Wiesloch
Bruchsal
Jaxtfeld
Carlsruhe
Mühlacker
Stuttgart
Nördlingen
Ulm
Augsburg
München
Kempten
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ADVANCES IN NAVAL ORDNANCE FROM 1855-1880,

A REVIEW:

BY

CAPTAIN T. J. ROCH, R.A.

"*Progrès réalisés par L'Artillerie Navale de* 1855 *à* 1880."
Coup d'œil d'ensemble, par M. CAVELIER DE CUVERVILLE, *Capitaine de Vaisseau.*

THE book before us only professes to be a sketch, and the fact of its containing no more than 51 pages proves that its title is no misnomer.

It is, therefore, not a history; but, on the other hand, to anyone who wishes to glance over the course of events which led us in the years above mentioned from the 68-pr. to the 100-ton gun, this little book has much to recommend it.

It is not my intention to attempt a *précis* of this work. It is itself condensed to the utmost, and I only venture here to call attention to its leading features.

M. de Cuverville starts with the year 1855, because it was in that year that the first French rifled gun was turned out. This—a gun of 16^{cm} (about 6 inches) calibre—was sent to the Crimea, but arrived too late to take any part in the siege of Sebastopol. Guns of this nature were afterwards placed on board the "Gloire," the first French armoured ship. These pieces continued to be the most powerful French naval guns up to 1866.

We, in England, were somewhat behind-hand at that date. In 1863, the 68-pr. was still our most powerful weapon afloat, and the only rifled guns we had in the Service were those of the Armstrong B.L. construction—of which the 7-inch was the largest—while their B. L. arrangement did not permit of much increase in the size of these guns.

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Meanwhile, to glance at the progress of armour :—

In	1865	we find the "Bellerophon" with	6	inches.
"	1866	" "Hercules" "	9	"
"	1869	" "Devastation" "	12	"
"	1870	" "Dreadnought" "	14	"
"	1874	" "Inflexible" "	24	"

(In which latter year, also, we find steel lending its aid to iron as an additional protection.)

And we may add "Duilio," "Dandolo," &c., 18 inches of steel.

It is interesting, now, to note how the early efforts of the French Artillerists were baffled by the want of a slow powder. Thus, in 1859, two R.B.L. guns of 16^{cm} calibre, called respectively the "Nivernaise" and the "Marie-Jeanne"—made of cast-steel and hooped—burst under the violent pressures given by the 24·5 lb. charges of quick powder with which they were fired. It seems beyond question that these guns would now be safe and serviceable, when we consider that the charge of our 6-inch R.B.L. gun, Mark II., is 42 lb. of the slow prismatic powder.

That this fact was not recognized for a long time it is now needless to say; but these guns afford a very striking exemplification of it.

M. de Cuverville points out how, in 1878, Sir W. Armstrong & Co. made a new departure with their 6-inch gun, and the guns which now are generally known as new-type guns may be said to date from then. This and the great strides made in the science of gunnery by Captain Andrew Noble and others are much dwelt upon in this little work.

Then comes a brief sketch of the old battle between M.L. and B.L. constructions, to which it is not here necessary to do more than allude. The question may to-day be said to be decided. Muzzle-loaders appear to have no future. But the science of gunnery advances rapidly, and, just as slow powders have revolutionized heavy ordnance during the last few years, so may another departure be made, and the guns of to-day be in their turn displaced by another "new type" in the days to come.

M. de Cuverville thinks that we are not likely to get beyond 100 tons in the weight of future armour-piercing weapons. But every gun which has been made has *pro tem.* been regarded as a finality, and I see no absolute reason why ships should not be built to carry 40 inches of armour—as is indeed now proposed—or even more. In which case, we may, before many years are over, be looking upon the 70-ton guns of to-day very much in the same way that we now regard the famous "Woolwich Infant."

However that may be, M. de Cuverville's little book—one may almost call it a pamphlet—sums up, in the course of a few pages, the vexed question of guns and armour up to the year 1880. It is written clearly, and contains much information, which, if not now quite up to date, is well worth reading. One might, perhaps, be inclined to suggest that one would like to hear a little more of Herr Krupp and his doings; but, on the other hand, it is satisfactory to see in what high

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esteem the names of British manufacturers and artillerists are held in France.

As regards the guns actually in the French service, a few words will not, I hope, make this short notice take up an inconvenient amount of space. The French have, like ourselves, found that they must remodel the whole of their Naval Ordnance. But from the fact of their having already adopted the B. L. type, which allows of chambers being enlarged, &c., more easily than does the M. L., their task may be a lighter one than ours.

At present, the most powerful gun which they have afloat is an old type gun of 34^{cm} (13·3 ins.). This gun weighs 46½ tons, has a muzzle velocity of 1640 f. s., and a penetrating power at 1000 yards of 19·3 ins. of iron.

Experimentally, they are very busy, and various guns of the above-mentioned calibre (34^{cm}), are in course of construction. The most successful of these will determine the future type. A 37^{cm} gun may be said to be in the service, though, as far as I know, none have yet been placed on board any ship. This gun, whose calibre is 14·56 ins., weighs 75¼ tons, has a muzzle velocity of 1739 f. s., and a penetrative power at 1000 yds. of 24·8 ins. of iron.

This gun is one of the most powerful Naval guns in existence. It will form part of the armament of the four big ships now building, the Admiral Baudin, &c., and compares as follows with our service 16-inch R.M.L. gun, which weighs 80-tons, has a muzzle velocity of 1613 f. s., penetrates at 1000 yds. 23·3 ins. of iron, and with Krupp's 40^{cm} (15·75 ins.) R. B. L. gun, which weighs 71 tons, and with a muzzle velocity of 1640 f. s., penetrates at 1000 yards 22 ins. of iron.

Guns of 42^{cm} (16·5 ins.) have been commenced in France; but it was decided to abandon them, and the parts already made will be utilized for 37^{cm} guns. It will thus be seen that in France, Naval Artillery is in a transition state. Every gun in their service, except the 37^{cm} would be called an old type gun, and the problem they are now endeavouring to solve is how to get more out of their old guns by means of suitable powders, and enlarged chambers and charges. With this view they are constructing several guns of 34^{cm} calibre and different dimensions, which seems a good practical way of arriving at a conclusion, provided expense be no object.

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THE TRAINING OF GARRISON ARTILLERY FOR THE ATTACK AND DEFENCE OF FORTRESSES,

BY

COLONEL H. A. SMYTH, R.A.

"et curæ sagaces
Expediunt per acuta belli."

GOLD MEDAL PRIZE ESSAY, 1882.

THE purpose of Artillery in the Attack and Defence of Fortresses is the same that has been elsewhere established for it in the operations of the Field, viz., to serve the needs of the other Arms, and, by smoothing the way for their action and counteracting that which may be opposed thereto, to bring about the success of *the whole*.

But this purpose, one and the same in its origin for both natures of Service, has become developed by them in divergent directions—for Fortress warfare, towards specific power—for the Field, towards opportuneness of action. The application of the specific power is determined, under certain obligations, by the mind of the Chief of the Artillery; but the efficacy of the application must depend on the proper service of the machinery which bears the power; in other words, on the professional fitness of the Artilleryman.

The professional fitness of a Garrison Artilleryman in the ranks is necessarily made up of the following principal constituents—innate courage, physical strength, endurance, discipline, skill—here stated presumably in ascending order of importance; likewise in the order of their successively increasing dependence on that primordial practice of armed force in every age, "training."

What constitutes training for the soldier? Undoubtedly, in an elementary sense, the putting into his possession the power of properly using his weapons; that is, in the first place, getting from them the best performance of which they are capable; and, in the second place, employing them in concert with others towards the fulfilment of the purposes of superior authority. On these twin principles hang all the teaching, the working, and the writing that have ever been, from the beginning, for the sound education of the soldier—for the development of raw material into instruments fit for the all-trying tasks of war.

The first-mentioned of the above functions includes the practical handling of an ever improving armament, together with special

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physical fitness; the second, readiness in combined movements, and discipline, together with general physical endurance. Underlying both of them, with momentous influence on their real value, subsists the moral nature of the individual. This nature may be largely affected, as to its ultimate character, by the application of moral training during the period of its growth, but not easily afterwards; and it is inexpedient here to discuss this kind of training, further than to note that the obligatory habits of the British military life (more especially in the Artillery, wherein is most maintained the essential concern of the Officers in the character and condition of their men) cannot but induce the spirit of just subordination, good faith, and soldierly honour, and thus favour the development of the highest military virtue—devotion to duty—which culminates in heroism.

The armament, of which the practical handling and application belong to the British Garrison Artilleryman, comprehends the whole of the "Service Ordnance"—from the machine-gun, the coehorn mortar, and the 7-pr. of 150 lbs. weight, up to the 17·72-inch gun of 100 tons—also rockets and hand-grenades. The authorised lists show 48 kinds of rifled pieces and 50 of smooth-bore, including both muzzle and breech systems of loading; their ammunition is of diverse forms, and includes 21 sorts of fuzes and 10 sorts of gunpowder, and the carriages from which they are to be fired vary according to the nature and purpose of each piece, under seven separate principles of construction. Besides these fighting-carriages, special transporting-carriages or apparatus, in like variety, are necessary for all the heavier pieces employed in Fortress warfare; also special machines for shifting, mounting, and moving them; together with instruments and material, in tackles, timber, and iron, for the convenient application of the primary mechanical powers.

Further, the charge and service of magazines, ammunition, and stores; the laboratory duties; the use of range-finders, telescopes, telephones, and field telegraphs; the judgment of distances, and of effect of fire; the handling and restoration of platforms, recoil wedges, hydraulic buffers, and anchorages—even the dealing on occasion with horses and their harness, boats and their gear, and (in this iron age) the equipment of rail and tramways—all fall within the office of the complete Garrison gunner.

The readiness in combined movements, and the state of discipline, demanded from the Garrison Artilleryman (under the second function of training noted above) include competency for long marches, prompt action, and precise formations; also, expeditious execution of his co-operative part, in any station, in any of the parties serving the weapons and machines above indicated. If each man can be relied on to perform his particular duty by day and by night, under all adversity of circumstances, whether of heat, cold, wet, privation, difficulty, discouragement, confusion, excitement, or danger from within or without—according to the orders of the Officer or non-commissioned officer in immediate charge of the party—then such Officer may direct with certainty the action of the unit he commands, in just concert with that of others, conformably to the instructions

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he may have received: and thus only may each unit fill its proper place in that scheme of ascending responsibility, by adherence to which an Army, complete in its manifold parts, becomes capable of working, as one whole, to carry out the purpose of its General.

The mention of one particular item of armament has been relegated to this place, because the weapon is often held to pertain at least as much to the disciplinary education, as to the service equipment, of Garrison Artillery, viz., the carbine, or other rifled small-arm, to be borne by each individual, as is the regular musket in the Infantry.

Concerning this weapon it is to be observed that the circumstances are hardly conceivable, in Fortress warfare, wherein it could be desirable for the gunner to desist from the service of the guns and employ his carbine against the enemy. In the interests of the interior economy of camps and garrisons, it may well be that he should still undertake the ordinary guard of his own quarters, parks, magazines, &c., and, for such matters of convenience, the establishment of a very small proportion of carbines with the Head-Quarters of each Battery, would provide; but, in the affairs of war, the law—that the Artilleryman best serves the purpose of the whole to which he belongs, by giving himself over completely to his Artillery duties, assured of just protection therein by the action of the other Arms—must be paramount.

If, then, the Artillery carbine comes to be recognised as an instrument for the purposes, not of active service, but rather of domestic training (inasmuch as there results from its exercises, and custody, and carriage on parade and in manœuvres with other troops, a fairly evident effect on the bearing and apparent discipline of the individual), it must be expected that the kind of spirit developed by its use will prove to be more suitable to the routine of peace-time than to the stresses of war. Traditional custom in the matter of supervision would no doubt undergo some derangement by the general withdrawal of the carbine from the Garrison Artillery: marching past would be less effective to the eye than heretofore; periodic inspection would see the gunners "on the guns" rather than "under arms," in the reality of shell practice rather than in the dumb-show of musketry exercises; but the display of ability would be more genuine, the effect in education more practical, and the men, relieved from supererogatory lessons, would devote a fuller and heartier energy towards the mastery of their proper, most weighty, yet sometimes most lightly regarded, duties.

So the Garrison Artillery, a special arm of Fortress warfare, would indeed become less interchangeable with other Arms, as it progressed in the development of its own peculiar powers: following therein the universal order of evolution, by which all the branches from a parent stem, the more they advance towards perfection, become the more definitely distinct.

It has been not infrequently proposed that the Garrison Artilleryman should undertake the duty of constructing his own Batteries; as is done in most Armies, but not in the British or Russian.

This scheme would demand increase of strength and additional courses of instruction. Has not the gunner enough to learn already?

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And can it be expected that he will pick up this additional art without losing any of his hold on the multifarious acquirements indicated above, which are proper to him, and for the exercise of which he exists? Will he not, in becoming a passable constructor, cease to be a first-rate gunner? Those who know the powers, and the ways, and the spirit of the soldier, will hardly gainsay this sinister conclusion.

On the other hand, the Engineers constitute a Special Constructional Corps, trained to such work, with the organization and machinery necessary for the application of the large working-parties of the Army. For all matters concerned with military construction, this Corps comes in as a friend in need and a guide to all Arms in their exigencies; not a fourth Arm, combining a distinct action of its own upon the enemy with that of the other Arms; but an element which should pervade them all, acting by and through them, and imparting to each, according to occasion, the spirit of skilled military ingenuity.

In all great businesses the principle of subdivision of labour—that is, well understood, distribution of tasks coupled with composition of products—has been found to afford the only sound economy: in war, the greatest of all businesses, this principle must be yet more imperative; and we may not hesitate, on consideration of the respective aptitudes of the two Corps concerned, to assign to the Engineers the duty of constructing the Batteries, to the Artillery that of arming and fighting them.

The active duties then, of which the trained Garrison Artilleryman should be master, are limited to those which pertain to the proper use of the armament denoted above, with its subsidiary machines. The catalogue of this armament is indeed far more comprehensive in the British than in any other Service; as it includes the whole range of weapons which in foreign armies is distributed amongst at least three separate branches of the Heavy Artillery, entitled respectively, Siege, Fortress, and Sea or Coast, Artillery; moreover, in France and Germany the first of these branches is ramified into the distinct organisations of a Light, as well as a Heavy Siege Artillery; and in Russia into those of the Investment, the Attack or Principal, and the Reserve Siege Artillery. Such positive subdivision of tasks must be likely to develop peculiar individual aptitude, which may on occasion return most advantageous results; but it is practically unattainable in the ordinary course of our Service, on account of the number and variety of its foreign stations, to the Garrisons of all of which a just rate of circulation must be secured, by means of periodic reliefs from the central force at home: thus our maritime empire, holding a girdle of heterogeneous fortresses round the world, demands in its Garrison Artillery an interchangeability for all natures of gun-service outside those which belong to the movements of the field.

The longest and most refractory-looking catalogue will become tractable under systematic classification.[1] To apply such method

[1] "Classify, and command," is the rule of the philosopher in dealing with the multitudinous forms of animated nature; thus adapting to the realms of science the old Roman maxim of progressive dominion "*divide, et impera.*"

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briefly to our catalogue of armament, it is to be observed, with regard to the land forces, that all the higher natures of guns belong to the Defence only; as their weight forbids their employment by the Attack, owing to the impracticability of moving them, under modern siege conditions, over ordinary country: and that, of these higher natures, the highest will be restricted to the sea fronts of fortresses (for action against armoured vessels); as their unwieldiness renders them ineligible for land fronts, owing to the difficulty of working them in action against the more numerous, handy, rapidly firing, and convergently disposed pieces of the besieger. The upper limit of weight for these natures is fixed by present practice at 100 tons; nor does it appear likely, under the great development of power realized by the use of large charges of slow-burning powder in long bores, as introduced under favour of the breech-loading system, that pieces of greater weight will become desirable.

The next class—comprehending all those natures whose weight lies, on the one hand, within the competence of a besieger to transport and to handle in the trenches, yet, on the other hand, beyond the capability of suitable movement in combination with manœuvres of the other Arms in the field—belongs to both the Defence and the Attack; but to the latter more particularly, as yielding the form of instrument on which a besieger must mainly rely. In this class also, the pieces group themselves according to weight, under two separate attributes: to wit, that of power adequate to the heavier tasks of Artillery in Sieges; and that of mobility sufficient for preliminary operations, as well as for application to advanced or other difficult positions, whether of the Attack or of the Defence: this latter group, of lighter natures, is distinguished from the rest of the class under the qualified titles of Light Siege, Position, or Investment, Artillery. The upper limit of weight for Siege Artillery proper is found now-a-days at about 80 cwt.: in the earlier part of this century it used to be placed below 60 cwt.; but, of late years, consideration of the general improvement of roads and communication which has accompanied the modern development of population and wealth amongst all civilized countries—together with a fuller recognition of the principle which should govern the transport of heavy ordnance, prescribing for it special carriages totally distinct in character from the fighting carriages—has sufficed to warrant, in most armies, such substantial addition to the value of this term: always of course with a large margin[1] either way, varying with (in the

[1] A weight of 80 cwt., under the ballistic arrangements of the new breech-loading construction, will afford a gun of remarkable range and accuracy, and of fair power against the lighter kinds of iron armour: for the attack of more massive armour, the methods available for the conveyance of heavier ordnance are indicated in the Report of 1881 by the Special Committee on Siege Operations, as follows:—

"To demolish iron defences, penetration in proportion to the thickness of iron to be attacked is required, but as in connection with fortresses of such importance as to justify the expense of iron defences, railways are almost sure to exist, means would thereby be afforded of bringing up guns of more than ordinary power; should railway communication not be available, jointed guns of high power afford the only direct means of destroying such defences."

This allusion to jointed (that is, articulating) pieces, whilst it points to a possible further

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words of the Ordnance Select Committee in 1864) "the nature of the operations to be provided for, and the theatre of war."

The third class comprehends all the "light" natures, which make up the remainder of the catalogue. Like the preceding classes, it presents two groups, distinct in weight and purpose: of which the heavier, under the name of "Field Artillery," exhibits the greatest ballistic power that is compatible with that celerity of movement which is necessary towards the sure combination of its action, in the field, at the critica ltime and place, with that of the other Arms; whilst the lighter group, known as "trench pieces," offers extreme mobility; permitting of the ready carriage, by man power alone, of its guns, mortars, howitzers and machine guns, into and out of cramped and sheltered nooks and corners of the advanced works or trenches, as the changeful course of close siege may dictate. The heavier of these two groups belongs to both the Defence and the Attack, but more especially to the former: because, although field guns may be largely used by both sides in the preliminary struggle for ground outside the fortress, yet thereafter the besieger will generally find little occasion for their employment, unless against sorties and other active enterprises of the besieged; whilst the latter may derive essential advantage from their application (on mobile, and perhaps disappearing, carriages) in the more advanced stages of the siege, particularly against sapping operations: moreover, the Attack may generally count upon receiving such assistance as it may require in this respect from the Field Artillery of the force which covers the siege operations. The lighter group also belongs to both Defence and Attack, and more especially to the former: because, although trench pieces are recognized as most expedient to the needs of both sides in the contest of the advanced siege at short ranges, yet at these stages the besieger will have behind him, independently of such accessories, a dominating Artillery power on which he may always rely; whilst the besieged may quite possibly find these small pieces to offer the only form of Artillery action remaining available to him. The upper limit of weight for Field Artillery is, in all armies, below 14 cwt.; the bottom of the whole scale, which is reached by trench pieces, lies at about $\frac{3}{4}$ cwt.

Thus the British Garrison Artilleryman, in regard to the Defence of Fortresses, should be competent to deal with all the ordnance of our service;[1] but more especially master of all that pertains to the use of

realization of power for the attack, moreover indicates an additional field for the industry and enterprise of Garrison Artillery.

Albeit, even without guns of individual power sufficient to the direct penetration of the armour attacked, there is no occasion for the Artillerist to mistrust the efficacy of his art. With shot of high velocity, effective weight, and good metal, suitably repeated, and artistically grouped, any construction yet put forward is bound to come to pieces: though less readily and economically than under the application of guns specifically appropriate to the task.

[1] As to the formidable length of the list of present service ordnance, it is no doubt to be observed that many natures now included in that list (especially of smooth-bore) must in good time disappear from it entirely, and that it will be found eventually shorter and simpler. Yet, on the other hand, other natures (especially of long breech-loaders) must be introduced; and the list is absolutely unlikely to present, for many years to come, that simplicity and symmetry which theory would enjoin. Those new breech-loaders will bring, to the recent lucid simplicity of the scheme of our Siege Train, the

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those natures which compose the armament of the fortress to which he belongs for the time being. And, in regard to the Attack, whilst he may well be acquainted with the working of all the pieces lighter than those particularly assigned to such purpose, he must be essentially proficient in the service and management of the ordnance belonging to our Siege Train, both heavy and light. Such expertness is more critically necessary to the Attack than even to the Defence; because the former has to combat superior weight of metal and protection by readiness in disposition and in working; without these properties the Attack may hardly, in these days of rifled accuracy and power, succeed in coming into action in such a form (as to disposition, simultaneity, and co-operation) as will yield reasonable grounds for expecting successful issue to the first (and, for the most part, the decisive) contest of Artillery.

To put soldiers of the average mental calibre through a complete course of regular instruction in the service of all ordnance, and of the machines and operations belonging thereto, would not only occupy too long a period of time, but would also result in their having forgotten the greater part of the preceding instruction by the time they had reached the end of the course, and the necessity would ensue of beginning it all over again; and so on, up to the end of their term of service. Therefore, in the tuition of our "general service" Garrison Artillery, the expedient must be adopted, of selecting only the leading types of ordnance and their appurtenances, and insisting on their use and exercise until the principles of the working of each are thoroughly mastered (therein carrying out the principle indicated in the introduction to the latest edition of the "Manual of Siege and Garrison Artillery Exercises"); thereafter, the gunners will remain capable and quick to become experts in those special branches of the work which the course of service may bring within their reach; that is to say, each gunner may then readily be made proficient in the Artillery duties of his own fortress; also in those of the Siege Train *if he be afforded the opportunity*. Such opportunity has hitherto been rare and capricious in the peace routine of Garrison service, and can only be secured on a satisfactory basis by special provision: such provision has been initiated within the past year, by the appropriation to each of our principal home fortresses of a "section" of Siege Artillery material, for instructional employment, and by the establishment of a regular course of Siege Artillery practice, to be attended by instructed detachments from each of the said fortresses. Concerning this course of practice, the Committee appointed to report on the question in 1880, recorded its opinion "that unless it is carried out under circumstances conforming as much as

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unwelcome complication of two opposite principles of loading, two opposite forms of service, ammunition, and stores—for a time, and perhaps for a permanency; for—whilst it is certain that the high velocity of projectile, which gives the best results in direct fire, is now conveniently attainable only with long breech-loading guns—there appears some reason to doubt whether the nice adjustment of ballistic conditions, which is necessary for the most profitable practice in curved and high-angle fire at various ranges, is to be obtained as readily with breech-loading as with muzzle-loading howitzers and (so-called) mortars: moreover, in curved fire especially, the service of the latter system is covered by the parapet better than is that of the former.

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possible to those of service, it would only tend to mislead, and could not give the officers and men any real information as to the power, &c., of the pieces they would be called upon to serve." The course would include the arming of Batteries, laying of platforms, service of ammunition, formation of siege park, &c., carried out according to the method of regular siege operations, and would last about a month: and the scheme appears to bid fair to meet the requirements of the case, if only it may be developed on a sufficiently large scale to allow of every gunner being passed through the whole course at least once during his tour of home service; and further, to include in the same transaction, a representative proportion of the other branches of the service, both combatant and subsidiary, and most especially of the Engineers; by which latter means each branch would learn to appreciate its proper place and purpose, the relations subsisting between the various departments, and the dependence of all upon the general principle of reciprocal co-operation. Abroad also this system of siege instruction, on a modified scale, would be advantageously applied to our principal fortresses; as their garrisons will no doubt be drawn upon in the future, as they have been in the past, in favor of any of our siege operations, whose magnitude or situation may appear to give the occasion.

Having thus far worked out, on positive grounds, the nature of the training required for our Garrison Artillery, together with the outlines of a scheme for its practical conduct, it becomes expedient to take cognizance of the counter-proposition, not infrequently advanced by the advocates of radical reform for our Military Institutions. "Much training is the ruin of individual spirit," so runs the allegation, "and by it are produced mere machines instead of intelligent and zealous soldiers. In the present opening era of universal education, the native material, from which our armies will be rapidly filled up on occasion, is already of so high an intellectual standard, that the laborious methods of a past age, for instruction in drill and discipline, are not only unnecessary, but moreover fraught with detriment to the intrinsic capabilities of the people for warlike action. The popular levies will learn their lesson quickly enough when the time comes; then why waste means and energy in keeping the force perpetually prepared, the bow always strung?" And with regard to the amount of training which should satisfy the needs of this special arm, it is instanced that, in the last and greatest days of smooth-bore achievement, Sebastopol was crushed out of existence by a Siege Artillery, which, taken as a whole, was neither highly trained, nor adequately prepared for the task which lay before it, and was moreover supplemented on all the more important occasions by drafts from the mounted branches: and that, on the establishment of the general use of rifled ordnance, 25 complete fortresses of France were reduced in the short space of six months, mainly owing to the power of the German Siege Trains, which were manned principally by the Landwehr and the Reserve, that is, by gunners who could not possibly have had regularly training with the new kind of Artillery, "a large portion of elderly officers and men," as Major Müller says, "to whom the rifled

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guns were quite strange:" whilst, as to the practice of earlier days, the time-honoured custom is quoted of the East India Company's Artillery, which, in so long a history of successful siege warfare, immemorially manned its siege pieces with gunners drafted from the adjacent Horse and Field Batteries of the movable force in the field.

The above proposition, like most statements of one side of a question, has a great deal in it, yet not enough; that is to say, it has not the other side as well. The exhaustion of individual spirit and intelligence by over training, must evidently be a question of degree; and it may safely be assumed that, the higher the intelligence, the more thorough the training which may be administered to it without detriment. The amount of training which is demanded by the circumstances of present-day war, may best be determined for each Arm separately, according to its special functions: for Artillery which is to engage in Fortress warfare, this amount must mainly depend on the value which is to be assigned to quickness of action—quickness in the preliminary operations of the park—quickness in the arming of Batteries—quickness in the opening and correction of fire. This value therefore claims examination; but first, in order to adjust the statement of the historical instances adduced, as above, in support of a reliance on intrinsic capability and extempore energy, it is to be observed—

With regard to the Siege of Sebastopol, that, though unquestionably the largest, it was by no means the most masterly exhibition of Artillery power recorded; and that, whereas it demanded for its course eleven months of open trenches, and between 60 and 70,000 tons of Artillery material, it is probable that—if the combined Heavy Artilleries of the Allied Armies could have been brought more quickly into action, so as to allow less time to the industrious garrison for the carrying out of its admirable offensive-defensive operations; and if moreover they could have been maintained in co-operative agency throughout one first day's fire, instead of losing early in the day the action of one half of the force, in such manner as to leave the remaining half to bear the whole weight of the enemy's fire—the place would have been taken by assault at the close of the first day's Artillery battle. It is also probable that—if, at the last, the operation of mounting five of the heaviest guns, which were intended to reduce the flanking defences of the Great Redan, and so prepare it for the impending British assault, could have been achieved instead of miscarrying entirely on two successive nights—the British columns would have reached the interior of that work in such order as to have been able to maintain themselves there, the retreat of the enemy's forces from the adjoining fronts would have been in a great measure cut off, and the credit of the British Arms in connection with Sebastopol would have taken a higher place in history than it owns to day.

With regard to the French fortresses taken in the Franco-German War, analysis of the circumstances shows that (with three notable exceptions) they were all deficient in the means requisite for offering a normal resistance to the Attack, as developed by the application of powerful rifled Artillery: as they were, in the first place, unprovided with such an outer defence of detached forts as has been determined

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(since the general recognition of the new powers of the Attack) to be necessary for preventing the establishment, by the besieger, of his first Batteries within decisive distances; in the second place, in a transition state as to Armament; and, in the third place, in a rudimentary condition as to Garrison, which was generally made up of heterogeneous elements, which had received very little preliminary training. Of the three fortresses excepted above, Metz and Paris became comparatively helpless, owing to their being overcrowded with defenders; and Belfort alone saw out the efforts of the besieger up to the end of the war, when it was surrendered by the orders of the French Government. Thus the remarkable results realized must be attributed rather to the unready condition of the Defence, than to the special efficiency of the Attack; indeed it is reckoned by German authorities that—had the Armies of investment round Paris and Belfort respectively, had at their disposal, proportionate and thoroughly organized Siege Trains, and thus been able to institute formal attacks forthwith—those places would most likely, in consequence of the extremely unready condition of the various elements of defence within, have fallen in less than the normal period of time, and thus brought the whole campaign to an earlier successful termination.

And, with regard to the old custom of the East India Company's Artillery, it is to be noted that the same included a regular annual course of Siege Artillery practice, very practically carried out, for all the gunners of the Horse and Field Batteries. Thus it must be reckoned that these men were well trained for the armament and purposes of their peculiar service; however impossible it might be to apply the system in European war at the present day, and to spare from the Artillery of the field a sufficiency of gunners to work even a moderate Siege Train.

To take up then the proposed examination of the *value of quickness in Artillery operation*; a matter which has always been insisted on in proportion as the application of the Arm to war has become developed. The securing of the initiative (that is, the opening a regular fire upon the opponent before he is ready to return it) and the establishment, from the commencement, of the superiority of fire (that is, the condition for annihilating, by concentrated fire, the offensive power of successively selected portions of the opponents Artillery dispositions, whilst their action is reduced to mere separate self-defensive reply) have been invariably recognized as more important, in Artillery contests, than simple arithmetical majority; and it is evident that, as the execution of the Arm becomes more absolute, and its performance more exact, the advantage—of being able to fire whilst unopposed, and to apply corrections whilst no smoke veils the field of impact, and no hurry or interruption embarrasses the practice—must be the more telling. But this advantage will be obtainable more frequently, more extensively, and with more important consequence, in the new forms of Fortress warfare than in the old; on account of the great extent and variety of the field of operations appertaining to the new order of fortification, which has followed necessarily upon the new conditions of Artillery action. The opportunities which concern this advantage will be evident

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on a brief recapitulation of the leading features of the modern regular siege.

The Fortress of the present day has ceased to be an indivisible whole, cased in a rigid ring of continuous strength, which is composed of a certain number of "fronts" of fortification. It has taken up that extension of dispositions, and adaptability to circumstances, which have been developed in all tactics under the pressure of recent improvements in fire-arms; and, though it owns still a central body (which acts as keep, and as reservoir for its defensive force in men and material) it is distinguished by such a forward disposition of detached self-defending forts, as must constrain a besieger to open his formal attack upon them, at too great a distance from the body of the place for his fire to be capable of reaching it with serious effect; and its extensive fronts are severalized only by their bearings, whether upon the strategic lines of communication, the larger features of the country, or the points of the compass. The detached forts are placed at an average distance from the body of the place, of more than 5000 yards, and from one another of 2 to 3000 yards, more or less, according to the advantages of the ground. With the vast perimeter thus occupied by the forts, the gaps between them are necessarily left open until the expectation arises of hostile aggression, (because the expense of closing them during peace time, by the old continuous methods, would put the whole system out of the question): thus the Fortress, in its permanent parts, represents only the skeleton of what it should become when threatened with attack.

The permanent works are the pivots on which must be based the system of active defence which is proper to such extended dispositions. When the time of immediate preparation against attack is arrived, the defender must give his first attention to the closing of the gaps between the forts on the fronts most threatened; in these spaces intermediate works must be established, which, themselves protected by the adjoining forts, are destined to render the approach to the latter more difficult; and they must be supported by more retired Batteries of a lighter and more movable character. For these constructions the rudimentary material will have been already more or less prepared, in the form of earthern epaulments or emplacements; and the resources of temporary fortification will suffice to complete them, and the necessary connecting lines, in a state of security against immediate assault.

If the defender can ascertain, in good time, the direction of the besieger's convoys, the place of debarkation for his material, the sites determined on for his parks, or the like, so as to form satisfactory forecast as to the front which has been selected for attack, he may be able, not only to prepare his positions in the first line, as above, but also to establish, and arm with Artillery, works in advance, and under protection of the guns, of the forts; thereby compelling the besieger to break ground at a respectful distance from their front, and, more particularly, forestalling any attempt at an "Artillery surprise" of the selected forts and their adjacent subsidiary works, which he might otherwise find means to make by hurrying forward the lighter pieces of his Siege Train (a latterly devised species of "Siege-Train Advanced-

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Guard") supported by plenty of Field Artillery, and so taking the first line under his effective fire before its armament and arrangements for the Artillery contest were completed.

For the gist, the "centre of gravity" (as the Germans forcibly term it) of the Defence, lies in the due maintenance of that first line. If the defender be forced back from it before he has had time to complete the preparation of his positions in rear, he must be rapidly driven in, from one position to another, upon the central body of the place; the farther he is pushed back, the narrower will be his front, and the more effective the converging fire of the besieger, up to the very last. If, on the other hand, the defender shall have established himself in the said first line soon enough, and with sufficient gun-strength to arrest the Attack at a distance, whilst he brings to the front the gun reserves which will become available to him from the unattacked forts as well as from the body of the place, he will compel the besieger to bring up the whole of the means at his disposal for the Artillery contest, and at least to expend vast labor and much time before he can force the Defence back from its chosen position; during which time the defender will be able to establish strong positions in rear, with satisfactory arrangement of the flanks, whether abutting on particular members of the chain of detached forts, or on natural features of the ground; to this retired position he may, if overpowered in the first line, withdraw the pieces yet remaining serviceable therein, besides bringing up additional gun-strength from the centre of the place, and be ready to receive the besieger as at first, and repeat the operation,[1] even again and again, if circumstances of ground, weather, relative strength, &c., favour him.

The concluding transaction of successful siege on any one of the permanent works of the defence, will offer little variety on those which have preceded it, except in the employment of adequate bodies of troops to effect the actual occupation in the interests of the besieger. Acceleration by surprise or by storm will be rarely attempted, because the end may be attained whilst the regular approaches are yet so far away as to afford little prospect of success to such enterprises; and the close fighting and advanced trench work of former days will, for the most part, be dispensed with.[2] Escarps will be breached, and caponières ruined, from a distance; and all cover searched out by Artillery fire arriving at all angles of descent and from most points of the compass; the works will be made untenable by any living thing, as was the Malakoff even in the days of Sebastopol, and the Fort of the Basses Perches at Belfort; and close observation will declare the

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[1] "Thus only" (says the Prussian *Jahresberichte uber die veränderungen und vorschritte in Militärwesen, for 1879*) "can the requirement be fulfilled, that, in the course of the Siege, every heavy and medium gun, and the greater part of the light ones, shall come into effective action in the special fight against the formal attack, before the enemy can proceed to the attack of the main *enceinte*; and this requirement, in our opinion, is essential to the spirit of the modern tactics of Fortress War."

And further "The tactics require, verily, from the defender, that he do not allow himself, when one or two forts shall have fallen, to be forthwith shut in to the main *enceinte*."

[2] Of the twenty-five Fortresses taken by the German Armies in the War of 1870–1, not one came to be stormed.

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moment when the prepared columns may dash into the almost untenanted works, and effect their lodgments on the mounds of shapeless ruin.

Against attack by sea, indeed, the action of the Artillery defence may diverge materially from the above methods; but it hardly claims examination here, it being self-evident that, where the target is exposed for the least possible space of time, and demands the greatest possible exercise of ballistic power (as in the case of the larger armoured steamers), quickness and precision of operation are of preponderating importance.

Thus it appears, from the whole recapitulation, that the operations of the Attack and Defence of a modern Fortress resolve themselves principally into a protracted and movable contest between the two Artilleries;[1] and that, apart from the question of overwhelming superiority in numbers or power, success must abide with that side which displays the greatest readiness in the disposition, quickness in the preparatory operations, and accuracy in the working, of its Batteries.

These qualities are directly produced by *training*. The nature of the training needful having been defined, and the extent of its application practicable in our service, having been indicated, in the earlier part of this Essay, there remains only to be considered the machinery by which such application is to be carried out. Are the gunners to receive their instruction in gunnery from their non-commissioned officers or from their Officers?

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[1] Doubts, as to the specific subservience of Artillery fire towards the reduction of modern defensive works, have come to be freely expressed since its failure in the most recent example afforded by actual service, viz., the so-called preparation of the position at Plevna by Artillery fire for the Russian assault of 12th September, 1877. But, on examination of the particulars, the case appears little to the point: because neither the pieces, nor the manner of employing them, were suitable to the occasion.

The Russian Artillery on the ground consisted of 24 guns of 15^{cm}, 120 of 10·6^{cm}, 160 of 8·6^{cm}, and 72 of 9 and 8^{cm}, 376 in all; of patterns affording good shell power but little range and accuracy; the 10·6^{cm} and the 8·6^{cm} guns especially being little efficient at ranges beyond 1700 and 1400 yards respectively.

These were disposed generally (122 of the lighter pieces hardly came into action at all) at distances of from 1 to 1½ miles against the Eastern front of the position, which extended over nearly 8 miles; they were intended to beat down the powers of resistance belonging to such a vast arrangement of works by general bombardment: after five days maintenance of their vague action, the guns ceased firing at the moment when the columns of assault broke from the trenches, with yet a mile of open ground remaining to be traversed between them and the lines of defence; the Turks immediately re-manned their works and disposed, without any difficulty, of the unprotected columns of the attack. So there was no force in the preliminary operation, and no co-operative connection between the two Arms concerned with the actual assault.

"Only on the left flank" says the searching analysis in the "*Neue Militärische Blätter of October, 1879*, was the Artillery well used, and only there had the Russian attacks any success. Not to the Arm, but to the misconduct of it, must be really charged the miscarriage of the enterprise."

Von Boguslawski indeed, followed by other zealous "Infanterists," has claimed for indirect musketry fire that it is now the most effective agent for quenching the offensive powers of permanent forts; but these views rest rather on the experiments of the practice-ground than on the experience of the field: and there can be little doubt that, if Infantry can deliver a fairly effective curved fire from certain distances, the same effect may be wrought with much greater certainty and expedition, from much longer or shorter ranges, and with less exposure, by a few good shrapnel.

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An intermediate measure will be readily suggested by the present course of the service, viz., that the gunners may be instructed by the non-commissioned officers under the supervision of their Officers; but it is evident, *in* the service, what such supervision dwindles to under the meagre provision of Officers present with Garrison Batteries; the charge comes to be considered as relating only to propriety and discipline, and, for practical gunnery purposes, soon ceases to be.

Non-commissioned officers are rendered capable, within limits, of administering the authorised instruction in the usual Artillery exercises, to the men, by the agency of an instructional staff of superior non-commissioned officers who have graduated for the purpose at the central School of Gunnery; these superior instructors are inexpensive, and always at hand; they are competent to take charge of the commoner heavy gun operations, as well as to overlook the drills conducted by the non-commissioned officers junior to them; and such a system may be worked, if without any special exhibition of zeal or despatch, yet with steadiness and sufficient convenience to the ordinary course of the service in peace time; the infrequent Officer still maintaining an ornamental and judicial connection therewith. Then, the question appears to arise, what is the use of the Officer at all, excepting in those higher grades that are necessary for the general guidance and administration? The answer is, the use of the Officer, the purpose of his creation, is, to direct his men *in war*. Each, in his degree, has precisely this function, neither more nor less, with regard to those subjected to his authority.

So severe is the strain, imposed by the circumstances of war, upon the natural instincts of man, so critical the emergencies, so serious the consequences; in fine, so great the call for devotion of self to the cause of duty, under conditions of discouragement, peril, or disaster, that the best material available for the directing element must be secured, whatever the cost. The intrinsic power of rising above natural instincts, is found mostly among the educated classes; and the spirit of adherence to recognised principle, in opposition to substantive advantage, immediate comfort, or the attraction of the moment—of loyalty to his order, and self devotion to approved purpose—belongs indispensably to the rank of "gentleman." This then is the class chosen for the material of the directing element in the British Army; when such material has received the requisite endowment of professional accomplishment, it presents the highest form of instrument for warlike purpose, the Officer fully fit to conduct his men in the day of battle. "The British Army is what it is," said the great Duke of Wellington, at a time when its repute for Military virtue stood first in the world, "because it is officered by gentlemen:" and, at the present day, however much the standard of professional knowledge demanded for the post of Officer may have been raised, there is no change in the underlying necessity of the essential spirit and principle.

Since, then, the gunners are to be worked, in the time of action, by their Officers, it follows that they should receive the needful training, during the time of preparation, from the same authority; in order that those who command, and hold the reins of discipline, and become responsible on service for the manner of execution of the required

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operations, may know, not only their work, but also their subordinates, and moreover be known by them; so that the military machine may work without hitch or friction, and with concert of all its parts; "so that each Commander of a unit" may, as General Skobeleff has expressed it, "know how to make the hearts of his soldiers beat in unison with his own before the battle." But the training to be given by the Officers should only be such as has direct regard to the operations of war, the elementary instruction and the exercise in details being carried out by their subordinates in the chain of authority; in order that individual spirit and the intelligence of all concerned should not become dulled by the monotony of too much mechanical routine.

Finally, there is to be taken into account the completion of the scheme of training, by inspection of the results, conducted by superior authority: the "General Inspections" which, according to the late Commandant de Chabannes, "are, of all the means for control and for impulsion, the most effective." Whether these may be conducted, on the principle already indicated with regard to the foregoing machinery of the training, by the higher officers of that branch which will be technically responsible for the results of Artillery action on service—without invasion on the domain of regular military discipline, or derogation from the authority of the General commanding—is an enquiry which would lead this Essay beyond its just limits: but the guiding principle of the inspection required is already sufficiently evident, to the effect that it should regard principally those matters which concern readiness for the operations of war; to wit, heavy Artillery operations and practice, as much as possible under Service conditions; and that it should concern itself as little as may be with the minutious economy of peace service and the specious display of ceremonial parades.

Still may be heard occasionally the echo of an earlier creed; roughly, it used to run, "Give your gunners good guns, good officers, and proper clothing, and British pluck will do the rest." The sentiment belongs to a bygone era, in which the valour of Britons perhaps ran no higher, but the force of circumstances certainly ran much lower, than at present. That the era was already past long ago, may be exemplified by the history of a certain body of naval gunners, who fulfilled all the conditions here specified, yet realised only unqualified disaster.

Of the quondam British frigate "Java," James's Naval History records that, on the 28th December, 1812, she "for the first time since she had become a British frigate, discharged six broadsides of blank cartridges. With the majority of the crew of course those six broadsides were the first they had ever assisted in firing." On the 29th, at 2.10 p.m., she came into action with the United States frigate "Constitution," nominally of equal force, but really more than half as large and powerful again. Twice, in the course of the action, the "Java" passed slowly under the stern of the "Constitution," almost touching; but the crew, "unable from sheer ignorance to appreciate the value of the opportunity thus afforded them," hardly fired a gun on either occasion. At 5.45 p.m. the "Java"—reduced to a mere shattered hulk, without masts or bowsprit, with half her people killed

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or wounded, a third of her guns disabled, and much water in her hold—surrended to her comparatively uninjured antagonist; and she was burnt, as unseaworthy, directly on the prisoners being got out of her. Foes abroad and friends at home (in Court-Martial) alike determined that the ship had been fought with the utmost gallantry, and that the Officers had displayed conspicuous zeal and ability: but there can be but little doubt that, if the crew of the "Java"—instead of having been hastily swept together a few weeks previously, of such raw material that the Captain "remonstrated about the inefficiency of his ship's company, but was told that a voyage to the East Indies and back would make a good crew,"—had been previously trained to but moderate efficiency in gunnery, and so been able to utilize the two commanding opportunities secured by the nautical skill of their Captain, the issue would have been reversed, and the little ship would have taken the big one.

The opposite style of training was that of the ships' companies of Nelson and Collingwood. The latter had brought his men, by constant practice, to the pitch of being able to deliver three well directed broadsides in three and a half minutes, and had taught them to believe that no enemy coming within effective range could withstand such execution; all the leaders laboured in the same direction; and in the supreme moment they received their transcendent reward. At Trafalgar, Collingwood took his ship singly into the crowd of the enemy, straight for his selected quarry, the flag-ship of the Spanish Vice-Admiral, and passing under her stern, poured into her, in the very nick of time and place, a broadside and a half of such crushing character as to lay low 400 of her crew, and to prostrate her great powers of offence: in vain her consorts closed around him to force him from his purpose; he undertook them all, until the arrival of his supports some twenty minutes later, when he turned to complete the subjugation of his chosen antagonist, and forced her to surrender after two hours of heavy all-round fighting.

Of such men the Latin poet (from whom this Essay has borrowed its motto) sang with prophetic vision, as truly as of the long line of warriors already past:—"the Gods, and forethoughtful cares, bring their arms to successful issue through the sharp crises of war": and, as time goes on and the warlike sciences become more and more developed, the inherent truth remains—only, in the expression of it, we become the more inclined to lay the emphasis, which Horace no doubt ceremoniously devoted to the first-mentioned of the two tutelary agencies, on the second.

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THE TRAINING OF GARRISON ARTILLERY FOR THE ATTACK AND DEFENCE OF FORTRESSES,

BY

LIEUT.-COLONEL F. G. BAYLAY, R.A.

"Semper paratus."

SILVER MEDAL PRIZE ESSAY, 1882.

From the days of ancient Rome up to our own times "Artillery" has ever played the most important part in the Attack of Strongholds and Fortresses, whether present in the form of the battering-ram or catapult of the Ancients, or in that of the pieces constituting a modern Siege Train. In the Defence likewise (at any rate in modern times) Artillery is an essential, if not the most essential element.

In these days, when Fortresses so often gravely interfere with the strategic movements of an Army in the Field, especially when situated on, or threatening, main lines of communication, their speedy acquisition by the assailant, or their prolonged defence by the Garrison, become matters of primary importance; and, since it is on the Artillery, either of the Attack or of the Defence, that the result must, in so large a measure, depend, the value of possessing a thoroughly efficient body of that Corps, specially trained in Fortress warfare, can hardly be overrated.

All experience goes to prove that, for troops to be effective in times of war, they must both be embued with a high degree of "*esprit de Corps*," and also have had the advantage of thorough training and practical experience, imparted and gained, in times of peace, under conditions resembling, as closely as possible, those of actual warfare.

The present organization of the Royal Artillery is adverse to a high degree of "*esprit de Corps*," or efficiency, being attained by the Officers of the Garrison Branch of the Regiment. It does not lie within the scope of the present article to enumerate the many reasons that might be adduced in support of this assertion; suffice it here to observe, that, even if we do succeed in training some of the Officers up to a certain

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point in, say, the Siege Train, by the time war is declared a large proportion of those so trained would be found serving in other branches, and their accumulated experience would be lost. In their place, we should probably have Officers ignorant of, and, therefore, disliking the Garrison work, and incapable for a long time of performing their duties efficiently. This is bad enough in any case, but when it is so with the seniors, on whom such grave responsibility must rest in the operations of a Siege, the consequences are proportionately serious.

When the present system was originated (in the good old smooth-bore days) all was simplicity and plain sailing, but now we have changed all that, and, however well the system might have worked under the former conditions, it is without doubt, desperately ill-suited to meet the requirements of the "Armed Science" of to-day, and must, year by year, become more and more so.

The absolute necessity for the separation of the mounted from the dismounted, so as to form distinct and separate Regiments, was brought forcibly home to the Germans by their experiences in the war 1870-71, and they at once acted in the matter; France is now following suit, and we shall surely have to do the same, if we really mean *to secure efficiency in the Garrison Artillery*.

The assertion may be a rash one, but the writer fully believes that there are few officers of standing and experience in the Regiment, who do not, in their hearts, endorse the opinion, that such a measure would, as a first step, do more to raise the standard of efficiency of the Garrison Artillery than any other that could be taken.

This, then, is the first measure which we would advocate; but, under any circumstances, we stand greatly in need of a "School of Instruction in Siege Operations," where the Artillery and Engineers could, conjointly, work out the whole question in a practical manner. It may be objected that we already have Shoeburyness and Chatham; true, and we could ill afford to dispense with those valuable institutions, but the weak point in each case is, that the land range or area available is too limited to admit of firing being carried out under Service conditions (as far as the works practised at are concerned) in the one instance, or at all in the other; a most fatal defect, as far as practical training is concerned.

Supposing such a School of Instruction to be established in a suitable locality, with a land range of ample extent to meet all requirements; it now remains for us to consider what course of training, theoretical and practical, would most conduce to efficiency in the Garrison Artillery, as far as Fortress warfare is concerned.

The theoretical training advocated in the following pages is intended to apply to the Officers only, and indeed it is only with them that we need seriously concern ourselves; for, given a body of highly trained and zealous Officers, we may safely rest assured that efficiency on the part of the men will follow.

The following may be indicated as suitable Heads of Instruction:—

General idea of the scheme of arrangement of the different Fortresses

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in the various countries of Europe, and also of the strategic value likely to attach to each, from its particular position and surroundings, in the event of an invasion taking place, from a given direction, having a definite object in view. The minds of the Officers will thus be led to appreciate the important part played by fortresses in modern warfare and they will be enabled to select for special study, those likely to exercise the greatest influence in future campaigns.

Many years must necessarily elapse before defensive works, embodying modern ideas, entirely replace those of older date. Thus, in the numerous sieges undertaken by the Germans in the war of 1870–71, the works attacked were, almost without exception, of antiquated type, and indifferently armed (chiefly with smooth-bore guns). It therefore behoves the Artilleryman in studying existing systems, with a view of gaining information regarding the conditions that would be imposed on the besieger in each case, not to set aside the older in favor of the newer systems, but rather to acquire a knowledge of the conditions that apply in both.

A careful study of the sieges of modern times (in connection with good maps and plans, showing features of ground, and works of Attack and Defence) should be made, and deductions be drawn from each.

With regard to this subject, it may be assumed that our Intelligence Department is in a position to furnish, approximately accurate, details respecting each and all of the more important Fortresses of the present day; amongst other items of information which might be enumerated, the following would be desirable, viz.:—

Good maps, on large scale, showing the topographical features of the country in which the Fortress is situated. The general trace of the works of the *enceinte*, and position of outlying works of Defence. Plans and sections of the different works. The armament. Accommodation for Garrison. Extent and arrangement of bomb-proof cover. Situation and extent of magazine accommodation. Permanent mines and galleries. Civil population residing within the lines of fortification. Nature of soil in those positions of ground over which an Attack would have to be conducted.

Furnished with such information, the Officers under instruction should be led to study the special features presented in each case, and to draw conclusions regarding—

The probable position of the Lines of Investment. The strength and composition of the Siege Train requisite. The considerations which would impose a limit on the weight of the pieces employed. Approximate amount of ammunition required for the different pieces. Considerations which should decide the choice of a base of operations. The considerations which would lead the besieger to select a certain front, or certain fronts, for Attack. The strong and weak points of the system of Defence. The tactical influence on the Attack of the outlying works of Defence, and the general plan of Attack that would consequently be imposed on a besieger. The probability, or otherwise, of being able to destroy the flanking Defences of the ditches by distant Artillery fire.

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It is urged that it is only by thus educating the minds of the Officers to solve varied problems of this nature, in times of peace, that we can expect to furnish them with the power of thoroughly grasping the situation when called upon to act, under analagous conditions, in times of war; and, when we consider the very great importance that attaches to the decisions that have to be arrived at by the Commander of the Siege Artillery, conjointly with the Commanding Royal Engineer, and that the success, or failure, of the Attack, must be mainly dependent on the soundness of these views, the great value of thorough sound previous training for the Officers becomes apparent.

The following subjects appertaining to the operations of a regular Siege should also be taken up and carefully studied, viz.:—

Position and organization of Artillery Parks. Objects of the First Batteries of Attack, and the considerations which decide the positions in which they should be established. Employment of Artillery and Machine guns to aid in repelling sorties. Objects of the Batteries of the "Second Artillery Position," and the considerations which should influence the besieger in selecting sites for the same. Considerations regulating rates of fire, and capacity and position of Expense Magazines. Proportions and supply of ammunition. Iron Defences—their influence on the Attack, and the means necessary to be adopted, by a besieger, for their destruction. Particular conditions of fire, for breaching purposes, imposed on a besieger by the profile and construction of different works. The power of Artillery to form breaches at long ranges. The influence of particular soils, or defective means of drainage on the Batteries and works of the Attack.

Space does not permit us to here enter further into the question of theoretical instruction, we therefore pass on to the subject of practical training (applicable to all ranks); such, we need hardly remark, should be thorough in every respect, and be made, as far as possible, to interest as well as to instruct.

The subject may be classed under the following heads, viz.:—

Guns and sights, of both light and heavy units.
Carriages and fittings.
Platforms, beds and anchorages.
Laying down the same.
Ammunition.
Stores.
Drills and shifts.
Various methods of laying.
Stowage of ammunition in Magazines and Batteries.
Moving, mounting and dismounting guns.
Method of disembarking Siege Train Equipment.
Arming Batteries by night, both by use of trench railway and otherwise.
Range finding and judging distance.
Annual practice.
Observation of effects of fire.

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With regard to stores; it is of great importance that the Officers in particular should thoroughly master the subject, and make themselves acquainted with the nature and proportions of the stores issued, not only with each piece, but with each unit of the Siege Train, and where they are to be laid hands on when required. Many Officers hold that a knowledge of details of this nature may be safely left to those in a subordinate position, but this is a grave mistake, which some have, ere now, discovered to their cost, when thrown on their own resources. After this digression we proceed at once to a consideration of the subject of "Practice," (including "observations of the effects of fire") as the nature of the instruction, included under the other heads, does not appear to call for any special remarks.

For the full value to be obtained from the Annual Practice, it is essential that it should be carried out under conditions resembling as closely as possible those of actual service, and against real works of fortification, so constructed as to impose on the Attack the various conditions of fire which might reasonably be expected to present themselves in future sieges.

It would be out of place to here enter into the subject of the exact nature of the works that should be constructed for this purpose, but an approximate idea of what would be required may be formed by perusing the account, given in the following pages, of the different series of practice recommended to be carried out by Batteries of Garrison Artillery undergoing a course of practical instruction in the Artillery operations of a Siege.

It may here be remarked that, after the first cost of the works had been defrayed, the amount required annually for repairs would not constitute a very serious item in the Estimates.

The following series of practice would afford much useful information, and would enable a large amount of valuable information to be gained regarding the effects obtainable, under varying conditions, on different kinds of masonry, earthworks, &c.

Series applicable to the First Artillery Position.

1. Distant fire from the First Batteries of Attack; practice to exhibit:—

a. The relative amount of accuracy and destructive effect of the fire of different pieces when directed against visible armament or works.

b. Relative efficacy of the different pieces when employed for enfilading long and strongly traversed faces.

c. Relative value of the curved and high-angle fire of the different siege train howitzers when employed for "searching effect."

d. Amount of accuracy and penetrative effect obtainable in the high-angle fire of the same when employed for the destruction of overhead cover.

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2. Effect of the shrapnel fire of guns on troops advancing in Attack formation over the open.

Such fire would be from positions commanding probable main lines of approach of sorties; the pieces employed being the lighter guns of the Siege Train (used as guns of position) also field and machine guns.

A few rounds of case might, with advantage, be occasionally fired from the guns to show the effect.

Series applicable to Batteries of the Second Artillery Position.

1. Curved fire of rifled howitzers, employed either frontally or obliquely, for breaching concealed revetments, at considerable angles of descent, by "demolition."[1]

2. High-angle fire of rifled howitzers, at angles of elevation not much in excess of 15°, for the destruction of detached walls or other works where similar conditions of fire were imposed on the besieger.

3. Practice to exhibit the relative effect of the shell fire of guns, and of howitzers with maximum charges, when employed for cutting down or destroying visible earthworks.

4. Destruction of the flank defences of ditches by means of the curved or high-angle fire of howitzers.

5. The fire of guns for "dismounting" purposes.

6. High-angle fire of light trench pieces from the advanced approaches for "surface effects."

7. Curved shrapnel fire of howitzers for searching effect, or to keep an already formed breach open.

8. Fire by night of various natures, including practice with illuminating projectiles, and when aided by the electric light (the latter more especially applicable to the Defence).

In series 1 and 2, the limits as regards striking velocity and obliquity of fire, imposed by the nature of the work fired at, and the weight of the projectiles employed, would be demonstrated.

It would not appear advisable to attempt to work out the whole of the foregoing series in any one season, but rather to select certain series for the practice of particular Batteries one year, and continue and complete the course of instruction and practice with the same Batteries the next.

In order to include in the course of instruction those particular series of practice which belong more especially to the Defence, it might

[1] The term "demolition" is applied to the destruction of a revetment by means of fire generally distributed over the portion of the wall intended to be breached.

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sometimes be advisable to extend the course over a third season, or to arrange the practice as follows, viz. :—

1st Year's Practice.—To include the series applicable to the First Artillery Position, and those applicable to the Defence.[1]

2nd Year's Practice.—The series applicable to the Batteries of the Second Artillery Position.

But any scheme submitted, must, in the first instance, be merely tentative, and be subject to modification as experience is gained: to resume then, those series which belong more especially to the Defence may be stated to be as follows :—

Series of Practice more especially applicable to the Defence.

Fire directed against the first operations, works and Batteries of the Attack.[2] Under this head would be included :—

a. Shrapnel fire of guns against troops or working parties in the open.

b. Common shell fire of guns at visible batteries, works and armament.

c. Curved fire of howitzers at batteries and works (both visible and screened) having in view the double object of destroying the parapets and traverses, and of searching out the interior of the works.

d. High-angle fire of howitzers for the destruction of magazines and blindages, and to search out gun portions.

Fire directed against the Works and Batteries of the Second Artillery Position.

This series would include fire carried out under the conditions laid down in *b*, *c* and *d* of the 1st series, the difference being that it would be at the shorter ranges corresponding to the Second Artillery Position.

Applicable to the close Attack.

Fire of field and of the heavier machine guns against the works and sapping approaches of the close Attack.

In the foregoing series the pieces employed should be those which might reasonably be expected to constitute the armament of inland fortresses; and the mode of mounting and the service of the pieces should, as far as possible, be the same as would obtain on service.

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[1] The reason it is proposed to throw these together is because they are both more short and simple than the series for the Batteries of the Second Artillery Position.

[2] Visible and screened, whether the cover was obtained from the natural features of the ground, or by means of artificial screens.

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All Officers of Garrison Artillery should, as soon after joining the Service as practicable, go through a complete course of instruction and practice at "The School of Instruction in Siege Operations;" and as a means of keeping up, and increasing, the practical knowledge of the Officers generally, it would be advisable that, as many as could be spared from the Garrison Batteries on Home Service, should yearly be sent to be present at a Course of Annual Practice carried out there.

The fire should, as a rule, be slow, careful, and deliberate; but as in certain stages of the Attack (for example, when the First Batteries of Attack are endeavouring to obtain a superiority of fire over that of the place) the fire of the besiegers would be as rapid as was consistent with accuracy, practice, under such conditions, should be occasionally carried out.

Every effort should be made to cultivate the faculty of correctly observing the effects of fire, an all-important point, and one on which efficacy of fire is mainly dependent. "Line" should be observed from look-out posts established in or close to the Battery. "Range" from advanced positions well forward, and to a flank; the observing parties at the latter posts being in telephonic communication with the Battery.

In breaching operations, when the escarp is surmounted by an earthen parapet, the amount of earth that has become displaced and fallen into the ditch, is, to a certain extent, a guide by which Officers may, and should be trained to, estimate the extent of the destruction wrought upon the escarp. So likewise the different appearances presented by shells bursting on impact, on different parts of the works, should be noted, and made to serve as a further means for judging the effects of fire (*Breaching Report, Siege Operations Committee, pp. 17, et seq.*)

Powerful telescopes and field glasses should be largely used to aid the observations, which should be invariably made under strictly service conditions, as otherwise their value would be largely detracted from.

Before entering on the practice, a careful study of the target works of fortifications, and of the ground over which the Attack will have to be conducted should be made. Maps of the ground, and plans, sections, and profiles of the works should be consulted, reconnaissances made, and the considerations which should decide the general plan of Attack, the positions and armaments of the Batteries (having regard to the conditions of fire suitable) be explained to those under instruction.

Officers should have impressed upon them the very great importance of taking advantage of the natural features of the ground, with a view to concealing the Batteries of Attack from the enemy's view, if such can be done without sacrificing the special object for which the Battery is constructed. As it is essential to secure good drainage, the features of the ground, in this respect, should not be lost sight of in selecting positions for Batteries.

Although the plans of the ground would probably afford an approximately correct idea of the distances of the Batteries of Attack from the works fired at, the use of range finders should not be neglected.

An Artillery Park should be formed, and the ammunition conveyed thence, and be stowed in the Expense Magazines and Batteries, before undertaking the operation of arming the Batteries.

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The Batteries should be armed by night; the operation being sometimes effected by means of trench railways, and at others with teams of horses, so that experience would be gained in both directions.

The men should be trained in laying platforms, beds and anchorages; although work of this nature falls, to a great extent, within the province of the Engineers. It would be well if they were also exercised in executing hasty repairs to works injured by shell fire, and be taught the advantage of having a number of filled sand bags kept handy to the Batteries (on Service), as a few of such, thrown quickly into a serious breach or crater, especially if existent in the overhead cover of a magazine, would often prove the means of averting a serious catastrophe.

The Officers should be trained to acquire the faculty of determining the proper elevation for securing a desired "mean point of impact" for the projectiles; the position of the "mean point of impact," calculated to yield the best results, should be decided on, before commencing any series of curved or high-angle fire.

During the progress of the practice, any defects in the guns, sights, carriages, platforms, ammunition, or *matériel* of any description, that may be observed, should be at once, and carefully, recorded; note should also be taken of any unsteadiness in the flight of projectiles.

Pauses should, from time to time, be made in the firing, to enable careful records of the effects obtained, to be made by Officers of Artillery and Engineers, selected for the purpose. Such records should be as complete as possible, and be illustrated with diagrams (such as plans and sections of breaches and craters) and with photographs of all more important results. These results should not be, at the time, communicated to the Officers directing the fire, who should be solely dependent on their own observations, and those communicated by the "look-out" parties previously referred to. At the conclusion of ceah series, the results obtained should be carefully reviewed, faults committed be pointed out, and resulting failures commented upon.

All Batteries in Camp should be led, as far as possible, to interest themselves in the whole of the series of practice carried out during their stay, (*i. e.*, not only their own practice, but also that of other Batteries). This is especially applicable to the Officers, who should never, except in cases of necessity, be absent from a practice.

On the termination of the year's practice, the whole of the reports should be submitted, with the covering report of the Commandant of the School, to the higher authorities for their information and decision.

A "précis," setting forth all the more important results obtained, should be prepared, printed, and published for the information more particularly of the Artillery and Engineers, though much in it would doubtless prove of interest to other branches of the service.

The value of such practice, in the carrying out of which the Engineers should, throughout, be closely associated with the Artillery, would, it is believed, prove to be nearly, if not quite, as great to the former as to the latter Corps, and if it be objected that the expense would be excessive, the difficulty might be met by Batteries only practising every two or, even, three years; Officers of other Batteries, attending, however, in the manner already suggested.

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We conclude this portion of our subject by remarking that experimental practice under a joint R.A. and R.E. Committee might, with advantage, be from time to time carried out at the proposed "School of Instruction," to gain information and practical experience regarding the many collateral subjects connected with the operations of the Attack and Defence of Fortresses.

Artillery of the Defence.

The following would appear to be the main points to which a Commander of Fortress Artillery should devote his attention on service, and on these the idea of training indicated is founded:—

He should acquire a thorough knowledge of the Fortress itself (especially of its weak points), and of the features of the surrounding country, paying particular attention to those over which an Attack might be conducted.

By a study of the strategical considerations which would probably influence the movements of an invading force, an approximately correct idea could be formed as to the side from which an enemy would advance against the Fortress, with a view to its investment; hence would become apparent the points of vantage which should be occupied and held by the Artillery of the Defence, in concert with other Arms; firstly, with the object of thrusting back the invaders, and so delaying the close investment, and secondly, to stave off the period of the close Attack. In short, the whole subject of the development of the front of Defence should be carefully studied beforehand, and decisions arrived at regarding the pieces best suited to meet the requirements of each particular case.

He should learn to appreciate the reasons which would actuate a besieger in selecting certain fronts for Attack, and be prepared to complete the armament of such fronts on the shortest notice.

He should be in constant communication with lines of outposts, well thrust out, especially at night, so as to enable him to gain the earliest and most reliable information regarding the enemy's movements, and be ready to open a sweeping shrapnel fire on working-parties breaking ground, should the operation be attempted within the effective range of that nature of fire.

Means for aligning the guns at night on those portions of the ground where it might reasonably be expected that this operation would be attempted should be prepared beforehand; and the quadrant elevation, due to the different ranges, be posted up in the Batteries for handy reference.

The use of the electric light and other means of illuminating ground should have been practised beforehand, and all be in readiness for the immediate utilization of this valuable aid to night-firing.

The arming of the front, or fronts, attacked should be proceeded with with the utmost vigour immediately it became apparent, beyond a doubt, which had been selected for the real Attack, and reserves of guns and carriages be collected in suitable and well-covered positions for use, as required, to replace those disabled.

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Elevated posts of observation should be selected, whence information regarding the disposition of the besiegers' works and batteries, and the effects of the fire directed against them, could be obtained. Failing good posts of observation (as church steeples, or other lofty buildings) or to supplement such, occasional observations from captive balloons should be made, which would enable more extensive knowledge to be acquired regarding the enemy's dispositions, than could be obtained by any other means: this would especially be the case if the features of the ground were of such a nature as to afford the enemy facilities for screening his works. The information obtainable by the foregoing means would be of paramount importance to the Artillery of the Defence, who should be trained in taking observations of this nature.

Ample reserves of guns, carriages, ammunition and stores, should have been collected in the Fortress before war was declared; to this point the attention of Commanders of Fortress Artillery should be particularly directed.

Throughout the Siege the expenditure of ammunition must be jealously watched; reckless firing be guarded against, and a nice discrimination exercised as to the proper times for making supreme efforts to crush the enemy. No hard and fast rules can be laid down in this respect, but it is an important point, and one that should not be lost sight of in the course of instruction.

Sites within the fortress, hidden from the besiegers' view by the works of the "*enciente*," should be selected for the erection of Batteries of pieces for curved and high-angle fire; such, from the difficulty which would be experienced in silencing them, would largely conduce to strengthen the Defence. Practice under similar conditions, having a definite object in view, should therefore be carried out in times of peace.

Permanent anchorages should be laid down in all positions where it was likely that guns on "disappearing" carriages would be established, the parapet being, at the same time, made up to a suitable profile, to afford the largest possible amount of cover to the gun. Arrangements of a similar nature should also be made for pieces mounted on travelling carriages fitted with hydraulic buffers.

As the extensive employment of pieces mounted on hydro-pneumatic carriages would largely increase the powers of the Defence, the Fortress Artillery should be thoroughly trained in working them, and also in the rapid moving into position of the various natures of pieces with which the fronts would be armed. They should also be from time to time exercised in the moving and stowing of ammunition,[1] and in the use of the lighter machine guns for the flank defence of ditches, and for arming retrenchments, and also with the heavier natures (such as the "Hotchkiss") for use against sap heads, &c. For the latter purpose, field guns would also be largely employed, being run by hand into suitable positions; they should therefore be included in the list of pieces with which the Fortress Artillery should be trained.

[1] Tramways leading from the magazines and depôts to the different Works and Batteries should be laid down.

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The use of field guns, mounted on "disappearing" carriages is also advocated: they would be difficult to silence, and would prove most effective against the sapping approaches of the close Attack.

The ranges of all salient features of the ground should be conspicuously posted up in the Batteries, and Officers and men be constantly exercised in judging the distance of intermediate points.

The course of training and practice, indicated in the foregoing pages, for the Artillery of a Siege Train should also be carried out in the Batteries acting as Fortress Artillery, and *vice versâ*, so that the Garrison Batteries would be prepared to render efficient service in either capacity.

Every Battery should pass through a complete course of instruction,[1] after which, according as they were employed, so would the training and practice, for the time being, take a particular direction.

Concluding Remarks.

For many years the particular branch of instruction for Garrison Artillery, treated on in the foregoing pages, was completely lost sight of and neglected in this country, but now we have the consolation of knowing that the subject has been, and is, engaging the attention of the military authorities. Much has already been done to improve and gain information regarding the "*matériel*," and a commencement has been made by establishing an annual course of instruction and practice at Chatham and Dungeness, to educate and train the "*personnel*;" let us hope, then, that each succeeding year may be marked by a progressive development and improvement in the means of instruction, and by a corresponding increase in the zeal and efficiency of this important branch of the Garrison Artillery.

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[1] Applicable especially to the Officers.

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NOTES
ON THE
EQUIPMENT OF HORSE ARTILLERY
FOR
SERVICE IN AFGHANISTAN, &c., &c.

BY
LIEUT.-COLONEL G. R. MANDERSON, C.B., R.H.A.

At page 150 of "Extracts from the Quarterly Report of Proceedings of the Department of the Director of Artillery for the half-year ending in September, 1881," under the head of "Equipment," the following appears:—

"Lieut.-Colonel Manderson, R.H.A., considers there should be no wheeled carriages in a Battery of Horse Artillery, except the gun-carriages, for service in Afghanistan."

The above extract requires supplementing to give the ideas on the subject which were entered in my Report, which were (as near as I remember, for I kept no copy of it), that a Battery of Horse Artillery *for service in Afghanistan* should have no wheeled carriages except its gun-carriages and limbers, and one spare gun-carriage and limber. The whole of the remainder of the ammunition, stores, artificers' tools, material for repair, line gear, &c., being carried on mules, led by native drivers, as in Mountain Batteries.

My reasons for the above, derived chiefly from the experience of the march from Jumrood through the Khyber Pass to Jelalabad with the first advance in 1878, when the road could scarcely be called one, and the only wheeled carriages that accompanied the Column were those of I/C, R.H.A., consisting of 6 guns, 6 ammunition wagons, 1 forge, and 1 store cart, all horsed, are—

(1) Because that, no matter how bad the road is, by dismounting the gun detachments, unlimbering, using drag-ropes, and man-handling in various ways, you can always manage somehow or other to get your guns and limbers over it; but wagons are much more difficult to deal with under such circumstances; and, having few gunners to assist them and inferior horses and drivers of less skill than with the gun teams, delay the Battery very much.

(2) If the wagons are not permitted to accompany the Battery in the Column they soon get into difficulties in mountain passes, and if ammunition is required from them it is extremely difficult to get them up, so soon blocked do the Passes become, whereas mules can be brought easily to the front.

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(3) The saving of expense by the substitution of native mule drivers for European wagon drivers, and in the matter of forage, &c., &c. I consider that all necessary stores, material for repairs, &c., can be carried on mules, except spare shafts, splinter-bars, and axles; these can be carried on the spare gun-carriage. Each ammunition mule should carry 12 rounds of 9-pr. ammunition. Afghanistan is not a country in which a Battery can move at any great pace for any great distance at a time; and, therefore, mules would be up with ammunition by the time that that in the limbers had been expended.

A Battery of 6 9-pr. R.M.L. guns of 6 cwt. (I stick to this gun for Afghanistan, because it is a capital gun up to about 1400 yards, and well suited for carriage on an elephant, on account of its general strength, simplicity, shortness, &c.) would be very efficient with the following establishment:—

5 Officers, 2 Staff-Sergeants, 6 Sergeants, 6 Corporals, 6 Bombardiers, 6 Acting-Bombardiers, 60 Gunners, 30 Drivers, 1 Farrier-Sergeant, 1 Wheeler, 2 Collarmakers, 3 Shoeing-Smiths, and 2 Trumpeters. Total European establishment, 130. 50 draught and 60 riding horses. 30 native mule drivers for 60 ammunition mules, 8 native mule drivers for 16 store mules (this includes 4 mules for a forge, such as is carried by Mountain Batteries), 10 native mule drivers for 20 line gear mules. This allows carriage for 2 blankets weighing 8lbs. each for every horse, besides his heel-ropes, &c. With a Battery equipped as above, with three-fourths of its ammunition on mules, only 15 elephants would be required to carry the guns, gun-carriages, and limber-boxes (if required to transport it over Passes having only footpaths), instead of 24, as hitherto necessary. And I added, in submitting my ideas, that had there been a Battery thus equipped at Cabul when Sir F. Roberts was selecting troops for his march to Candahar, he would probably have taken it with him.

I cannot refrain from again remarking on the excellence of the Mark II. 9-pr. gun-carriages, wagons, and limbers. The only damage done to the 14 carriages of the Battery that made the march with the advanced Column to Jelalabad in December, 1878, over difficult Passes, and the worst roads I have ever seen guns go over, was 10 spokes, more or less injured.

I would here note, too, how desirable it is not to have large horses in the Service. Horses *on service* are always more or less on "short commons" (or, if not on "short commons," they get fed so irregularly, and often after fasting so long, that they fall off in condition), from which large horses suffer much more than small compact ones. I do not think that either at home or abroad anything is to be gained by having any horse for Horse or Field Artillery or Cavalry beyond 15-3. A team of six compact horses of that height is equal to any work required in dragging a 6-cwt. gun, its limber, &c., and will fare far better in the above conditions of service and do more work than a team of 16-1 or 16-2 horses; besides which, small horses get less knocked about on board ship than big ones. As regards pack mules,

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too, for similar reasons, and for facility of loading and unloading, they should not exceed 13-3 in height—about that size they are far more suited for pack-work in the hills, and take much less out of themselves, over difficult ground, than bigger mules do.

Having now and then seen poles advocated for Field Artillery in lieu of shafts in the R.A. Institution Papers, I will state briefly my views on the subject, having served in the field with the late Bengal and Madras Artilleries' systems of pole-draught.

The advantages claimed for poles over shafts are, I believe,—

(1) Greater uniformity in harness throughout the Battery.
(2) The strength of two horses to keep back the carriage instead of only one, with some slight assistance from another.
(3) Greater facility in extricating a wheel horse shot.
(4) Wheel horses, for the pole system, are easier procured than shaft horses.

The disadvantages of the pole system are,—

(1) The carriage is not so well under control as with shafts.
(2) It is almost impossible to prevent having weight on the pole horses' withers, making them likely to come down if they stumble, &c., and often producing collar galls.
(3) As regards extricating a dead horse on service, there is not much delay if you use a knife to the harness, which you would do were time an object.
(4) In the Bengal system of pole draught it was difficult to reduce the weight on the pole horses' withers below 2 stone each. In the Madras system it was much less, but the collar-bar was not so serviceable as the Bengal one (in the Bengal system the breechings were fastened to the collar-bar, which was as long as the splinter-bar; in the Madras system they were fastened to the hames, and the collar-bar was only about half the length and weight of the Bengal one; in both systems there was a ring at the bottom of the hames, through which the collar-bar passed, and which held up it and the pole; the Bengal was therefore the more secure system, as in the Madras system everything in pulling up, &c., depended on the ring; its collar-bar, however, had the advantage of being much lighter than the Bengal one), and the carriage was much lengthened, as there was a perch on the back of the limber to limber up to: this certainly took some weight off the pole horses' necks, but it is very disadvantageous lengthening your carriage.
(5) With drag-shoes, drag-ropes, and gun detachments there is no difficulty in assisting horses in steep descents, and if in manœuvring the pace is reduced to a walk before halting, *as ordered,* the shaft horse should be equal to halting the carriage.
(6) As regards the supply of horses suitable for shaft purposes, it

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is more probable that—as generally in most countries greater care is taken than formerly in breeding horses—their number will increase rather than decrease; and at the worst we must remember that in the first Afghan War the shaft horses of Leslie's Troop of Bombay Horse Artillery were only 14-2 Arabs, and they answered admirably.

I will conclude a paper already too long, by a few ideas on a working and fighting dress for a Royal Horse Artilleryman at home or abroad.

(1) His head-dress should be a cork helmet, colour dust or French grey, it should be light and well-ventilated, give *ample protection* from sun and rain, and be of such a shape as not to interfere with his laying a gun. By protection from rain, I mean that when it is raining, and there is no wind, the water will run off the helmet quite clear of the neck, ears, &c. A black oilskin cover for the helmet, to be carried inside it, would be useful for very wet weather.

(2) He should have a patrol jacket made pretty loose, with pockets inside the breasts—none in the skirts—and a groom's waistcoat, the sleeves of which could be taken on and off, fastened through eyelet holes. He would then have five dresses according to temperature, viz:—

Patrol jacket and waistcoat with sleeves.
Do. do without sleeves.
Do. alone.
Waistcoat alone, with sleeves.
Do. without sleeves.

(3) He should have pantaloons and knee-boots as at present, the pantaloons being made nice and loose above the knee, and having pockets. In India his boots of all descriptions should be kept brown, the same colour as harness, and preserved in the same way, with soap. They would be much cooler and more comfortable than if blackened, the blacking-brushes and blacking could be expunged from the kit, there would be fewer flies in barracks, saddles would not suffer from the blacking off knee-boots, and they look remarkably well.

(4) A "Sam Browne" brown leather sword-belt to wear under his patrol jacket, and stout cream tan hunting gloves, and a wooden scabbard for his sword.

I am doubtful about the material for the patrol jacket, waistcoat, and pantoloons—some advocate corderoy, but perhaps a good description of blue cloth would, after all, answer the purpose, and the red stripe and some yellow braid might be retained.

At all events, the above dress would be most comfortable, give the men the free use of their limbs, and protect the vital parts, which it is so necessary to do for men exposed as soldiers are to all sorts of weather. In his present dress, a Horse Artilleryman has no sooner mounted his horse or lifted the trail of his gun than he has to pull down his jacket, and he cannot even go through the extension motions without unbuttoning a great portion of it.

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RAILWAYS IN WAR.

A REVIEW;

BY

LIEUTENANT J. M. GRIERSON, R.A.

"*Die Kriegführung unter Benützung der Eisenbahnen und der Kampf um Eisenbahnen;*" *von* H. L. W. KGL. PR. HAUPTMANN.

PART II.

RAILWAY TROOPS.

THE second part of the book under review is devoted to the Organization of Railway Troops, and the Attack, Defence, Destruction, and Repair of Railways. The former, the youngest branch of the Service, is as yet unknown in the British Army, although represented in those of almost every Continental Power. The American War first showed the necessity of such formations, and in every Campaign since then their value has been fully proved. As in most other matters, in Germany the organization of the Railway Troops is most perfect. They form a Regiment of two Battalions of four Companies, with 1050 of all ranks, quartered near Berlin, and Officered partly by Engineer, partly by Infantry Officers. The men are trained in all branches of Railway Engineering, in constructing and destroying lines, telegraphs, tunnels and bridges, and work in squads under their own non-commissioned officers. To complete their instruction, detachments are constantly employed in the construction and repair, both of State and private lines, by which means the cost of such works is greatly reduced. But not only must Railway Troops be trained in constructing lines of rail, but in working them also; so with this object the German Railway Regiment disposes of a line of its own from Berlin to the practice range of Cummersdorf, about 28 miles long, with five stations, which is worked entirely by Officers and men of the Regiment, who thus gain a valuable insight into the practical working of Railways, which would be of the greatest use in a hostile country where tho Railway employés had been withdrawn. The Germans calculate that one Company (6 Officers and 200 men) would be required for every 45 to 60 kilomètres of occupied Railway. In imitation of the Germans,

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France, Austria, Russia, Spain, Italy and several minor States have now specially trained Railway Troops in their Service, into whose organization we have not space to enter—England alone stands aloof. Doubtless such duties would be most efficiently performed by the Royal Engineers, but what with their Pontoon, Telegraph, Field, Fortress, Survey and Torpedo Companies, the question is "Whence are the men to come?" It would be satisfactory to see an actual Railway Company organized in peace, with a good expansive organization for War, as has frequently been proposed by Officers of the Corps. But there is another Branch of the Service from which valuable aid might be afforded, we refer to the Volunteers. To utilize the services of the enormous army of Railway employés simply as Rifle Volunteers, is a sheer waste of power. There are several Corps composed of these men, and a Railway Volunteer Staff Corps exists. Why should not this Corps be backed up by Volunteer Railway Battalions? which, being under Military control, would be of inestimable value in case of invasion, and, we believe, in case of a Continental War also. The means lie ready to our hand; it is our own fault if we fail to utilize them. The same remark applies to Post Office and Telegraph Corps,[1] which ought properly to belong to the Engineer Branch of the Service.

Attack of Railways.

Railways may be attacked with two objects in view; to secure their use for one's own side, or to prevent their use by the enemy. As a general rule, the defeat of the enemy's Army is the object to be aimed at in active operations; but cases often arise in which a line of rails may become the objective of an Army acting on the offensive, the capture of which has a decisive effect. To secure possession of a line of rails with a view to using it with the least possible delay it is necessary to act with secrecy and rapidity. The chief engineering works (bridges, tunnels, &c.) and junction stations should be seized to prevent the enemy from destroying them. For those operations, Cavalry (armed with carbines) supported by a few Horse Artillery guns, and Infantry in carts, will generally be selected. In all cases a few Engineers (miners) should be added to such a force to search for prepared mines, &c. A good example of this species of attack is the occupation of the bridge of Barboschi by a party of Russian Cavalry, followed closely by guns, and Infantry, at the opening of the last War. Orders for such operations can only be given by the Commander-in-Chief of the Army.

The attack of a line of rails, when the object is to prevent the enemy from using it, is one of the most difficult operations in warfare, both for the leaders and the troops. Such an attack must be kept secret, or success is doubtful and danger certain. The leader of a party told off for such work should be brave but cautious, energetic, with an eye for ground, and with quick powers of decision. Such men were Stuart, Morgan, and Grierson, the famous leaders of raids in the American

[1] Such as the 24th Middlesex Rifles, whose signalling parties have attracted so much attention.

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War. With their Corps of two or three thousand Mounted Riflemen (for the American Cavalry were little more), supported sometimes by a few guns, those Officers made raids, sometimes lasting for weeks at a time, against the lines of communication of the enemy's army, living on the country, breaking up Railroads, and spreading terror and confusion before them by the rapidity and dash of their movements. For such operations the best and most seasoned troops only should be selected, as the fatigues to be borne are sometimes extraordinary. Their composition must vary according to the country they have to move through, and the general situation. In such cases good Mounted Riflemen would be invaluable, but, if much opposition be expected, guns and Infantry to hold points to cover the retreat must often be added. The more difficult the operation is, the more independent must the detachment be. A body of Mounted Pioneers or Railway Troops should invariably form part it. The situation of a Railway with regard to the enemy's front will greatly influence the mode of attack, as it is evident that a line running to his rear perpendicular to the front is much more effectually protected by the Army than one trending away to a flank. Wide turning movements will have to be made to reach the line with a view to destroying it, or the enemy's front may be broken through. There are two main periods in which the attack of the enemy's lines of rail is most advantageous: (*a*) during the concentration of his forces, and (*b*) during operations when the transport is most strained, *e.g.*, retreats or transfers of large bodies of troops from one theatre of operations to another. In the former case, the frontier lines used for the concentration would be attacked; the best points being the detraining stations, the destruction of the works (extra platforms, store-houses, &c.) at which would cause great confusion, and the line itself behind those stations. The stations would probably be occupied by the enemy, and a strong mixed force would usually be required, but the line is best attacked by small parties of Cavalry. If the offensive be not intended, the destruction of larger works, such as bridges and tunnels, may be attempted. Thus, in 1866, the line Prevau-Oderberg-Oswiecim was cut by destroying one viaduct and two bridges by Knobelsdorf's detachment, and the Austrian communications between Galicia and Bohemia were thus interrupted. In 1870 little was attempted by the Germans beyond cutting telegraph wires and breaking up the lines, except in one case in which the viaduct of Rohrbach, on the Hagenau-Saargemund line was destroyed by a party of 30 Uhlans on express orders from Berlin, to separate the Northern from the Southern group of the French Army of the Rhine. Had the Turks in 1877 destroyed the Barboschi Bridge, the Russian operations would have been most seriously delayed, as three months' work, at least, would have been required to re-construct it.

In the second case, when the transport on an enemy's line is most strained during operations, the enemy's line must be outflanked or broken through. Thus, while the Austrian Army was effecting its retreat from Olmütz on Vienna by rail in 1866, Hartmann's Cavalry succeeded in breaking through the troops guarding the line and cutting the Railroad at Prevau and at Göding. In 1870, while Canrobert's

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Corps was being pushed up to Metz from Chalons, the Prussian Cavalry succeeded in cutting the line at Dieulouard and at Pont à Mousson. A large part of the Army Corps, including the ammunition columns, was forced to return to Chalons, a fact which had an important influence on the result of the Battle of Gravelotte, as this very Corps, holding the right of the position, fell short of ammunition at the most critical moment of the engagement. On the 25th August, 1870, the Mezières-Thionville line was cut by the Brunswick Hussars to prevent Macmahon communicating with Thionville. The Regiment that day performed a march of nearly 60 miles. Again, on the 31st August, the Mezières-Rethel line was cut by the Germans, thus breaking Macmahon's communications with Paris. As a last example, after the defeat of the Army of the Loire at Orleans, when it retreated in two directions, to the south and west, the Railway was destroyed at the important junction of Vierzon to prevent communication between the two Forces.

Orders for such destructions can only be given by the Commander-in-Chief of the Army, who alone is in a position to grasp the general strategic situation, and to decide whether the Railway will eventually be required by his own Army. Subordinate Commanders have frequently given order for the destruction of Railways which have later on caused the greatest inconvenience to *their own* Army. Thus, in 1866, the viaduct of Königinhof and the bridge of Prevau were totally destroyed by the Prussians, although a partial demolition would have served the purpose equally well. The Prussian Army was thus deprived for the remainder of the war of an alternative line of communication which would have been of incalculable advantage to it had operations been continued. The chief points of attack are stations, great engineering works, and certain sections of the line, such as curves, junctions, &c. The choice is influenced by the use which the attacker intends to make afterwards of the line. The orders must state most clearly the extent of the destruction to be carried out. On approaching a line, the greatest caution must be observed, and all localities avoided. It is therefore advisable to be quite independent of the country, and to carry forage and rations. In all cases, a point for rallying should be named in case the party be surprised and broken, and a good look-out should be kept while the work of destruction is going on. If a station be the point of attack, the rails on both sides should first be cut so as to prevent the withdrawal of any rolling-stock which may be in it. Should a train be attacked, the rails ought first to be removed to bring it to a standstill, as experience has shown that firing at a train in motion has little or no effect.

Defence of Railways.

Railways may be defended with two objects: (*a*) to secure them for one's own use; (*b*) to prevent the enemy from using them. In the first case, the best means is the strategic offensive. If this cannot be undertaken on all points, then the defence of the line must be intrusted to barrier forts, or to special troops. Sir Garnet Wolseley, in his

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"Pocket-book for Field Service," says,—"The nature of the country, the character of the enemy, the composition of his army, and the disposition of the inhabitants can alone determine what number (of troops) will be required, and what is to be the proportion of Cavalry to Infantry, &c., &c. The more Mounted Infantry that can be spared for the work the better. It is folly attempting to guard a line by distributing along it 10 or 12 men to the mile. Central points must be selected as positions for flying columns, ready at all moments to move out, either by train along the line, or on horses, or in wagons along the country roads, to pounce down by forced marches upon the enemy's columns. The position of these flying columns to be changed constantly. Small Cavalry parties should scour the country to the right and left of the line to the greatest possible distances compatible with their safety, telegraph stations being pushed out, and signal stations posted on commanding ground still further out, so that it should be impossible for any movement to be made by the enemy within the zone thus watched, without its being immediately known to the several flying columns . . . . The most vulnerable points of railroads . . . . are large tunnels, viaducts, and bridges. In many instances it may therefore be necessary to protect them by blockhouses, containing small garrisons of from 20 to 100 men, each being commanded by an officer . . . . A mitrailleur, with a good supply of ammunition in each, would add greatly to their powers of defence." Such, in a few words, are precisely the ideas of the writer of "*Die Kriegführung, &c.*" Above all, the terminal station of a line should be most carefully protected by works at some distance, the station itself being only used as a *reduit*. In it, and at the principal stations, abundant means should be provided for repairing the line should it be broken. To prevent the inhabitants of an enemy's country from aiding in the destruction of a line, it should be proclaimed that the village nearest to any destroyed point will be burned. Inhabitants should be well paid for any information of intended raids brought in.

In the second case, measures will generally be taken in peace, on home lines, to destroy them should the country be invaded, or to block them by barrier forts. Large Railway junctions should invariably be protected by works. Barrier forts must be of permanent construction and large enough to hold a few hundred men and a few heavy guns. They should be so strong that siege guns would be required for their attack, completely free from escalade, and well provided with flank defence in the ditches, bomb-proof cover, magazines, and store-houses. If an invasion be threatened, it will be necessary to destroy the main Railroads leading from the enemy's country. Thus, in 1870, when an invasion of South Germany was feared, the Rhine bridge at Kehl was blown up by the Germans. Orders for such destructions can only be given by the Commander-in-Chief. A last means of rendering Railways useless to an invader remains to be noticed—the adoption of a different gauge, as in Russia. Fortunately for an invader of Russia, the gauge of the Russian railways is larger than that of those of other countries. There would therefore be no difficulty whatever in laying a third rail

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between the other two to fit the smaller gauge of foreign carriages, while the Russians would find the greatest difficulty in providing their rolling stock with axles to fit the narrower gauge of foreign lines, and it would frequently be impossible to widen their gauge without entirely relaying the line.

Into the details of the destruction and re-construction of Railways, the work done in various Campaigns by Field Railway Detachments, and the Reconnaissance of Railways, with which "*Die Kriegführung, &c.,*" concludes, we do not propose to enter; but we heartily recommend all those who take an interest in the important question of Railways in War to procure this most excellent work, and read it for themselves. We have found the greatest difficulty in condensing the valuable matter contained in the book, and again express a hope that it will soon be translated into English in its entirety.

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A REPORT

ON

PRISM RANGE-FINDERS,

BY

LIEUT. A. H. RUSSELL, U.S.A.,

Under the direction of Col. T. T. S. Laidley, American Ordnance Department.

(REPRINTED BY PERMISSION.)

SIR,—I have the honour to make the following report on the prism range-finders submitted to me by the Chief of Ordnance in the fourth indorsement, April 11, 1881, on my letter of December 14, 1880:—

The three prisms are herewith returned, viz.:—

1. The original Weldon range-finder from London.
2. The modified Weldon range-finder described in Ordnance Notes 134.
3. The six-sided prism proposed in the above letter.

The first was found to be valueless, as it does not give constant angles.

The second operated as described in Ordnance Notes 134, and it was found to be subject to the same inconveniences as were there mentioned—the necessity for taking a back sight in observation, and its limitation to a single base.

The third, or six-sided prism. *The principles of reflection are the same as for the Weldon prism.*

The following description of the prism is, for convenience of reference, taken from a former letter:—"Figure 2 is a horizontal section of the prism. The faces A B and E D are parallel. The angle A is equal to the acute angle desired. B C makes with E D half the angle A, and C D makes with A B half the supplement of A. The angle C is 90°, and E F makes with A B an angle of 45°. Light following the course from I to J gives a deviation equal to A; that following the course from I′ to J′, a deviation equal to the supplement of A; and that from I″ to J″, a deviation of 90°. The parts shown in heavy lines are silvered, and all the portions bounded by double lines are covered by the frame."

Figure 1 shows the instrument in perspective. A is the prism, B the frame; *a*, *b*, *c*, *d*, and *e* are the apertures for observation; *l*, *l*, *l*, the clamps which retain the prism in place; and *m* is the ring to which the string may be attached. Near each aperture is shown an arrow-

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mark to indicate approximately the direction in which the observer should look into the prism. The aperture at *a* has two of these marks, the right-hand one for use in connection with the aperture *b*, and the left-hand one with the aperture *c*. The aperture *e* is used in connection with *d*, *b* with *a*, and *c* also with *a*. A square, marked on the surface between the apertures *d* and *e*, indicates that they correspond to a right angle, and the acute-angle mark between the apertures *c* and *a* indicates their use together for laying off an acute angle. The apertures *a* and *b* are used together for laying off an obtuse angle. No handle is provided, but the instrument is to be grasped by the sides between the thumb and forefinger, usually of the hand opposite the object seen by reflection. The tip of the finger should usually cover the aperture opposite to the one into which the observer is looking, in order to cut off coloured rays which might interfere with clear vision. For instance, while looking through *a* and obtaining the reflection through *b*, the observer should cover *e;* and while obtaining the reflection through *c* he should cover *d;* while looking into *d* he should cover *a*, &c. The proper image to be selected is easily found, as it remains steady, while other images which may be seen move very quickly when the prism is turned horizontally.

. . . . . .

"In obtaining the distance of the object C (Fig. 3), an observer at A lays off the angle C A E, obtaining the reflection of the object C with the acute angle of the prism, and at the same time looking over the prism in the direction of the base A E; then advancing along the line A E (without turning round) and using the obtuse angle, he stops when he reaches a point, B, where he sees the reflection of the object C in the direction of E." If the right angle be used the observer makes his first station at D and his second at A or B, as he can use either the acute or the obtuse angle in connection with the right angle. It is perhaps better to make the forward station first, as the observer can probably keep his alignment more readily by moving backward and so increasing his distance from the point sighted on. Where the whole base A B is used, multiplying it by 20 gives the distance; where half this base is used it should be multiplied by 40.

Careful measurements, with corrections for errors of observation, give the following values for the angles of the prism :—

Angles required.	Angles obtained by measurement.
A, 88° 31′ 3″	88° 34′ 5″
B, 135° 42′ 58″·5	135° 43′ 50″
C, 90°	89° 59′ 20″
D, 134° 17′ 1″·5	134° 17′ 20″
E, 135°	135° 0′ 20″
F, 136° 25′ 57″	136° 25′ 5″

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Notwithstanding these errors in the angles the results shown in the table were obtained by observations at Fort Monroe and Sandy Hook, in some cases the multiplier 20 being used, and in others the multiplier 40, the latter case being, of course, more liable to error on account of the use of a shorter base. The instrument can be used like the Weldon range-finder, by observing only with the acute angle, if desired.

Distance.	Error.	Multiplier.
Yards.	*Yards.*	
686	+ 7	20
752	− 5	"
685·5	+ 8·5	"
686	+ 13	40
1,075	− 50	"
*1,822	+164	"
1,822	+ 98	"
*1,933	+147	"
1,933	+ 27	"
2,918	− 98	"

* The first observations at the distances of 1,822 and 1,933 yards were made under inconvenient circumstances, when the sight was uncertain. The repetitions were more accurate.

The greatest base used in these measurements was 73 yards, and usually it was not over 40 yards, while in the trials of the Watkin range-finder, described in Ordnance Notes 116, the shortest base was 63 yards, and most of the bases exceeded 100 yards, the greatest being 128 yards. The longer the base used the greater the difficulty in finding the proper ground for observation.

As indicated in my letter of March 15th, three triangular prisms might be substituted for the one six-sided prism, and with this arrangement the method of observation might be learned rather more readily, as there would be no need of covering up the apertures, while the field of view would be somewhat enlarged. Figure 4 shows such an arrangement: A, B, and C are triangular prisms made on the Weldon principle—A for a right angle, B and C for acute and obtuse supplementary angles, respectively. The frame D supports the three prisms. It is doubtful, however, if any real advantage would here obtain over the six-sided single-prism form.

Of the mirror telemeters giving fixed angles, that of Azémar, described in the report on telemeters submitted by me to the Ordnance Office in January last, seems to be the simplest. This was made to give two angles, one acute and the other obtuse, supplements of each other. It is shown in figure 5 with the addition, suggested in the

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above-mentioned report, of an additional fixed mirror for giving a right angle. If only two angles are used, an acute combined with a right angle would be better than the two supplementary angles, as the advantage of having a right angle would be secured without necessitating back sights in observation.

The modified Azémar telemeter consists of a small frame, L M N, on which are placed four plane mirrors reaching from the top to the bottom of the frame; this frame swinging between two plates of brass, G K, it being pushed out and in by turning it about the pivot P. The mirrors L, Q, and M make with the mirror N angles less than, equal to, and greater than 90° respectively—the greatest and least angles being complements of each other. Such a telemeter commends itself by its cheapness, but a prism telemeter gives far greater clearness to the image, while, unlike the mirror telemeter, it is not subject to derangement.

The above experiments justify the recommendation in Ordnance Notes 134 of an arrangement for reflecting right angles in connection with another fixed angle like that in the Weldon instrument, and show also the advantage of having an additional angle supplementary to the acute angle. It will be useful for other than telemetric purposes for the officer to have the means of measuring a right angle, since it will be convenient for setting out perpendiculars, and will enable him to align himself between two points without depending on an assistant. In the use of the above telemeters an assistant is undoubtedly useful, but these instruments, which do not require back sights to be taken, are not so dependent as the others on such assistance.

It is proper to refer here to a paper by Col. A. W. Drayson, R.A., F.R.A.S., printed in the "Proceedings" of the R.A. Institution for January, 1881. He says:—

"Having had an instrument constructed fifteen years ago by Messrs. Troughton and Simms, identical with that which Major Weldon has lately invented, and having given both the instrument and the method a very extensive trial at Woolwich and Shoeburyness before committees, and at Aldershot, I consider it may be of some interest if I give the results of my experience connected therewith.

"Finding that persons unused to instruments had some difficulty in setting the index of a sextant to any given angle—such as 84° 17′, 87° 8′, or 88° 34′—I consulted with Mr. Simms, of the firm of Troughton and Simms, as regards constructing a small instrument like an optical square, which should by reflection show these angles only. These opticians turned me out four instruments; one an optical square set to show 90° only, another to show 88° 34′, a third 87° 8′, and a fourth 84° 17′.

"After a long series of trials I selected the optical square and the instrument showing 87° 8′, and I used these in the following manner:—

"The optical square was used to set off the right angle between the distant object and the second observer. The instrument showing

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87° 8′ was used to place the second observer so that the distant object coincided in the object-glass of the instrument with the observer using the optical square. The range of the distant object was then 20 times the base.

"The base may be paced if great accuracy is not required, but it ought to be measured.

"For measuring I used a stout tape on a large roller, and when gunners or private soldiers used this an error in multiplying sometimes occurred. For example, suppose the base was 69 yards, I have been given the range as 1,280 yards instead of 1,380. To avoid this source of error I requested Messrs. Elliot, opticians, to construct for me stout tape, on which *half* yards were shown and numbered, so that a base 69 yards long would be shown on the tape and read as 138 *divisions*. No multiplication was then necessary, as the range was read off at once by annexing 0, and was given as 1,380 yards.

"The first practical difficulty I encountered with this method was, that if the range should be as much as 4,000 yards the base must be 200 yards long, and to find a position for a base of such length was often impossible in enclosed country; or, if the base could be obtained, the distant object, the range of which was required, could not be seen from both ends of the base.

"In order to have a choice of positions I usually carried the instrument showing 88° 34′, and when a base of 200 yards for a 4,000-yards range was not obtainable I used a base of half the length and the angle 88° 34′, when the range = base × 40.

"Owing to obstacles, the nature of the ground, &c., I found that a fixed base of $\frac{1}{10}$, $\frac{1}{20}$, or $\frac{1}{40}$ the range was most inconvenient in rough country, and so I gave up this method in favour of that requiring a variable angle and any convenient base, the optical square being used as before to set off the right angle, and the pocket sextant being used to measure the acute angle—a table being used to read off the range.

"After many years' practice in all countries I have found this method the best and most convenient. The errors, with competent observers, vary from 1 to 3 per cent., and the time occupied varies from 1 to 3 minutes.

"Captain Everett, 33rd Regiment, who was my assistant at the Royal Military Academy, could with me find a range in less than 40 seconds, and with an error rarely more than one per cent., and such results were obtained before a committee at Shoeburyness.

"In all these methods, however, it is necessary, from the principle of the instruments used, that the base should be horizontal or nearly so. In hilly country this is almost impracticable, and great errors will result.

"In order to obtain the full benefit of any range-finder thoroughly competent observers must be employed. To hope that any method of

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range-finding can be used by men who are unskilled is a delusion. So that it really seems desirable that there should be attached to each battery men trained as range-finders, receiving some small increase of pay when thus qualified.

"We do not expect that every gunner should, after an hour's instruction, be competent to shoe a horse, and the value of knowing one's range so as not to waste ammunition is certainly of sufficient importance to demand training and attention.

"The method of using the fixed angles and variable base, such as 88° 34′, 87° 8′, and 84° 17′, I taught at Hythe to the School of Musketry, also at Aldershot, and at Woolwich about ten years ago; also, the more useful method of any angle and any base in order to overcome the defects of the fixed angle.

"It will be seen from these facts that the Weldon range-finder is not quite a novelty, and from the supposed perfection of the instrument and the method it appears that its practical difficulties have not yet been discovered."

This opinion as to the difficulty of using fixed-angle telemeters is similar to that expressed in Ordnance Notes 134, though there are undoubtedly many cases where they would be very useful. It is thought that the method of use suggested by Lieutenant Sedgwick Pratt, Third Artillery, U.S.A., may materially increase the value of fixed-angle telemeters. An outline of this method is here given as applied in general to telemeters with fixed angles. It enables the observer to obtain the distance between two points even when he can occupy neither of them.

The observer being at C, figure 6, to obtain the distance between the points A and B, he lays off the bases C C′ and C C″, as if to determine the distances C A and C B respectively. Without measuring these bases he measures the distance C′ C″, and this multiplied by the number corresponding to the instrument, 20 for instance, will give the distance A B. This is because the angle C′ C C″ is equal to the angle A C B, and the sides C C′ and C C″ are proportional to the sides A C and B C in the triangles C C′ C″ and A B C. Care must be taken to lay off the bases in the same direction from C, that is, both to the right or both to the left of the observer at C as he stands facing the points A and B for the two bases respectively.

Where the instrument is adapted to laying off a right angle also, the observer can place himself on the line between two points, A and B, figure 7, and obtain the distance between them in a very simple manner. Being at C, he lays off in the same direction the bases C C′ and C C″, one corresponding to the distance C A and the other to C B, adds the bases and multiplies their sum by the usual number.

Lieutenant Pratt's instrument consists of four mirrors. Two are set at an angle of 45° and two at a lesser angle. The number of mirrors is the same as in the modified Azémar instrument, which gives three angles. The bases are $\frac{1}{10}$ and $\frac{1}{20}$ of the distance to be determined, and with the longer base the instrument is used like Weldon's.

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FIG 1.

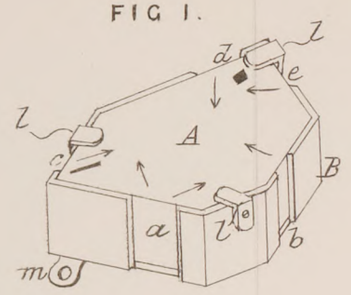


FIG 2.

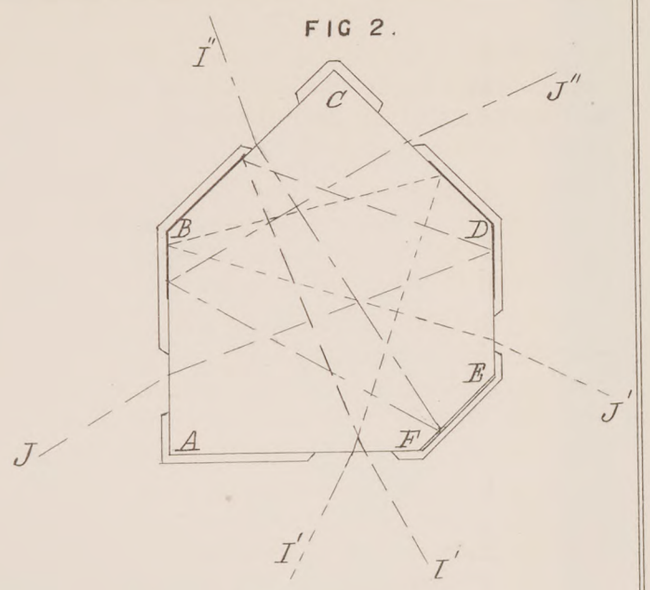


FIG 5.

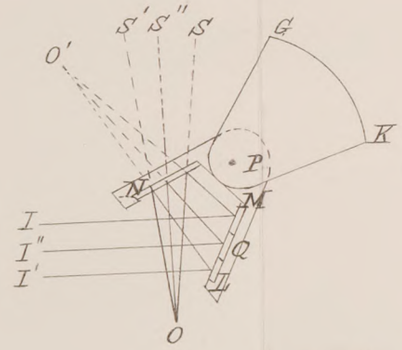
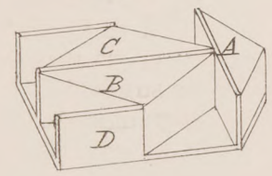


FIG 4.



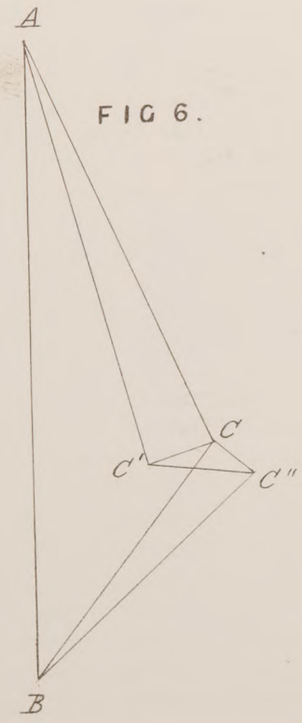


FIG 6.

FIG 3.

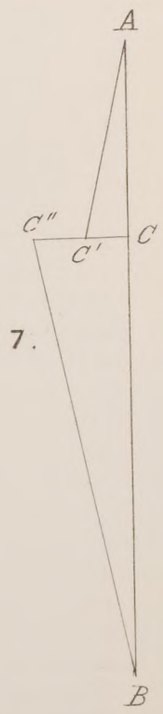


FIG 7.

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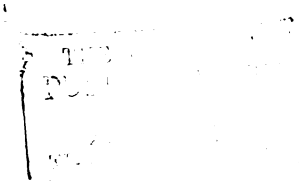

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The method shown in figure 6 is applicable to the Weldon range-finder as well as to those giving a right angle. When the right angle instruments are used, care must be taken to lay off this angle at the right or at the left extremity of the base in both observations. When A C C′ and B C C″ are both right angles the line C′ C′ will be perpendicular to the line A B, and this affords an easy method of laying off a perpendicular to an inaccessible line, two points of which are visible to the observer. This method can be used also with variable-angle telemeters.

Thanks are due to Capt. W. S. Starring, Ordnance Corps, to Lieut. Sedgwick Pratt, and Lieut. Constantine Chase, Third Artillery, for assistance in the above observations, and to Professor Melville, of Harvard College, for measurement of the angles of the prism.

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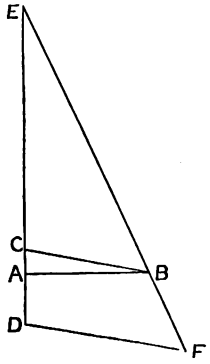
APPROXIMATE QUADRATURE OF THE CIRCLE,

BY

CAPTAIN J. C. DALTON, R.A.

Problem.—To draw a straight line that shall be equal to the circumference of a given circle.



Let AB = diameter of the given circle. Draw through A a straight line EAD, perpendicular to AB.

Let $AB = d$

and make $AC = \frac{d}{5}$

$AD = \frac{2d}{5}$

$CE = 2d$.

Then $AE = \frac{11d}{5}$

$ED = \frac{13d}{5}$

Join BC, and through D draw DF parallel to CB and meeting EB produced in F.

Then EF shall be equal in length to the circumference of the circle with diameter d.

Because DF is parallel to CB—

$$\therefore \quad \frac{EF}{EB} = \frac{ED}{EC}. \quad \text{Now } EB = \sqrt{d^2 + \left(\frac{11}{5}d\right)^2} = \frac{d}{5}\sqrt{146}$$

$$\therefore \quad EF = \frac{\frac{d}{5}\sqrt{146} \times \frac{13d}{5}}{2d} = \frac{13d}{50}\sqrt{146}$$

$$= d \times 3{\cdot}1415919\ldots.$$

and as $\pi = 3{\cdot}1415926$, the error is ·0000007, which is inappreciable.

Q.E.F.

The above was extracted from the "*Mittheilungen des Artillerie-und-Genie-Wesens*," by the Spanish "*Memorial de Artilleria*" for August, 1881, where it appears with several printers errors, which I have corrected.—J. C. D.

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ON FIXING POSITIONS

BY THE

MORE SIMPLE ASTRONOMICAL OBSERVATIONS,

FOR THE USE OF

R.A. OFFICERS ENGAGED IN EXPLORATION,

BY

MAJOR E. S. GORDON, R.A.

NOTE.—The above paper (R.A.I. Proceedings, No. 7, Vol. XI.) having called forth some observations in a contribution (No. 2, Vol. XII.) by Major Oliver, R.A., I think it well to correct, at once, in a short note, some remarks in the latter relating to instruments treated of in my paper, which otherwise might be misleading to Officers contemplating their use in Geographical Research.

I.—THE SEXTANT.

The Sextant

Major Oliver's statement that the sextant is "awkward to hold," "difficult to manage," &c., is negatived by the universal authority of practical Geographers and Explorers by land and sea. On the contrary, the sextant is capable of performing, even in moderately skilled hands, with ease and accuracy, all operations required by Officers who wish, at small cost, and carrying light weight, to determine Geographical Positions from Astronomical Observations.

For comparison—as to *weight* and *cost*, with the transit theodolite (the 5-inch, as recommended by the author) I subjoin a table, by which it will be seen that these advantages are altogether with the sextant. The theodolite, by reason also of its relative bulk, and consequent non-portability, is a far less convenient instrument, especially over rough ground.

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The patterns in this table are those adopted by the Royal Geographical Society, and lent to travellers:—

Instrument.	Weight.	Cost.
(1) Sextant, 4-inch, complete, in case	4 lbs.	£7
(2) Sextant, 6-inch, complete, in case	7 lbs.	£12
(3) Transit Theodolite, 5-inch, complete, with illuminating apparatus, and tripod stand	33 lbs.	£36

For valuable hints on the manipulation of the sextant, see a paper by (the late) Captain Haig, R.A., in "R.A.I. Proceedings," "On the Employment of the Sextant for Observations requiring great precision."

II.—The Artificial Horizon.

Mercurial Horizon.

The "George" pattern, adopted by the Royal Geographical Society, and made only by Cary, 181 Strand, in which a glass disc covers, and floats over, the mercury, is entirely free from the "tremor" alluded to by Major Oliver; and although much smaller than the patterns which he mentions as being "much too small," is now, on account of its great portability, and other advantages, (see printed reports) in almost general use by explorers.

III.—The Chronometer.

Chronometer.

The "Chronometer shewing Greenwich Mean Time" does not exist. The *accumulated rate* must, in every case, be computed and applied.

The subsequent statement that "it keeps a different rate travelling to what is does when stationary," is not borne out by those who have used the pattern watch of the Royal Geographical Society in all climates, and confirm the fact of the extraordinary uniformity of its rates under every condition. As an instance, see "R.G.S. Proceedings," March, 1882, p. 136.

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ABSTRACT OF THE PROCEEDINGS

OF THE

FORTY-FIFTH ANNUAL GENERAL MEETING

OF THE

ROYAL ARTILLERY INSTITUTION.

THE 45th Annual General Meeting was held in the Theatre of the Institution on Tuesday, 30th May, 1882, Maj.-Gen. *Hon.* E. T. Gage C.B., Comdg. the Woolwich District, in the Chair.

I. The Notice convening the Meeting was taken as read.

II. The Abstract of the last Annual General Meeting was taken as read.

III. The Forty-fifth Annual Report, which was as follows, was read:—

1. The Committee beg to submit the 45th Annual Report of the Royal Artillery Institution.

2. There are now 1586 Members of the Institution, as shown in Appendix A, against 1558 in the previous year. 79 Officers joined during the year, while the deaths and withdrawals amounted to 38.

The number of deaths was only 15, against 39 last year. Among them are to be noted those of General C. J. Wright, Colonels *Hon.* R. C. H. Spencer and H. Jervis-White-Jervis, and Captain D. W. Pack Beresford.

3. The accounts have been audited this year by Major Wethered, Staff Paymaster, and Major Piers, Paymaster, R. A.

Appendix B shows that the financial condition of the Institution is very satisfactory.

The amount of work done during the year may be judged to some extent by the magnitude of the totals of the Cash Account, £2450 18s. 11d. having passed through the Secretary's hands.

The General Credit, shown in the Capital Account, is £3072 19s. 4d. against £3014 10s. 10d. last year.

Appendix C has been made as full and complete as the records permit. The number of Members, in the second column, includes those retired from the Service (and re-elected), as well as those on the

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active list. The third column gives the absolute Income of the Institution; that is, the amount of Entrance Fees and Subscriptions received during the year, and the Interest of Funded Property. An inspection of these two columns shows that the Institution has been steadily progressing since 1855. Some apparent irregularities in column IV., Expenditure, are explained by column V., Amount in Funds. For instance, the Expenditure in 1874–5 appears as £1475 against £908 in the previous year. The explanation of this extraordinary increase is, that £314 was lodged in the Funds in the latter year, and had to be shown as Expenditure.

Columns VI. and VII., must always vary irregularly. But the best evidence of the popularity of the Institution is afforded by column VIII.; and the Committee point with satisfaction to the fact that the percentage of Members on the active list was greater last year than it has been since 1855, when membership was practically speaking compulsory.

4. The Landscape Drawing Class has retained its popularity. Classes and individual Officers have been assisted by Institution funds at several out-stations for the study of Spanish, Italian, Russian, Turkish, and Landscape Drawing.

5. The Committee have continued the supply of Foreign Military Periodicals to Members willing to furnish from time to time, for publication with the "Proceedings," Reviews and Précis of their contents, as well as Translations in full of important articles.

6. The subject selected for the Prize Essay of the year was "The Training of Garrison Artillery for the Attack and Defence of Fortresses." Six Essays were submitted for competition.

Maj.-Gen. S. E. Gordon, C.B., Colonel Nicolls, and Colonel Betty, were good enough to act as Referees.

7. In accordance with the decision of the majority of the Judges, the Committee decided to adjudge a gold medal to the author of Essay, Institution No. 6, and a silver medal to the author of Essay, Institution No. 5, provided that these Essays do not exceed the prescribed limit of 16 pages.

8. The Committee hope ere long to publish a volume of the late Lieut.-Col. Cleaveland's Notes upon the History of the Regiment, embracing the period from 1716 to 1763.

9. The Committee were fortunate enough to be enabled to purchase a handsome ivory miniature of the late Sir Alexander Dickson, G.C.B., which is now hung in the Reading Room of the Institution.

10. The Thomas Calculating Machine (arithmometer), purchased to assist Officers in making out Tables, &c., has fully realised the anticipations of the Committee.

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11. The following Lectures were delivered during the year:—

The March from Kandahar to Ghuzni in 1880, and a short account of the Battle of Ahmed-Khel	Lt.-Col. E. F. Chapman, C.B., R.A.
The Attack of Armour-clad Vessels by Artillery	Captain C. Orde Browne, late Royal Artillery.
Outline of the Progress in Construction of Heavy Guns	Major L. Downes, R.A., Inst., Rl. Gun Factory.

12. The following changes in the Committee took place during the year:—

Colonel W. H. Goodenough...	vice	Colonel W. N. Waller.
Major R. C. Drysdale	"	Lieut.-Col. J. E. Blackwell.
Captain J. R. J. Jocelyn	"	Major W. G. Brancker.
Lieut. C. S. B. Parsons	"	Lieut. R. C. Foster.
" A. M. Murray	"	Captain F. Roberts.
Lieut.-Col. H. B. Maule	"	Colonel W. H. Goodenough.
Major J. H. Blackley	"	" R. Oldfield.
Lieut. F. J. A. Trench.....	"	Captain C. W. Long.
" R. A. Bannatine	"	Lieut. A. M. Murray.

The Committee at present (1st April, 1882) is constituted as follows:—

PATRON AND PRESIDENT:

Field-Marshal H.R.H. The DUKE OF CAMBRIDGE.

VICE-PRESIDENTS:

The Inspector-General of Artillery.
The Director of Artillery and Stores.
The Deputy-Adjutant-General, R.A.
The General Officer Commanding Woolwich District.

MEMBERS:

The Assistant-Adjutant-General, R.A.
The Director of Artillery Studies.
The Assistant-Adjutant-General, Woolwich.
The Secretary, Department of Director of Artillery and Stores.
General W. J. Smythe, F.R.S.
Lieut.-General Sir J. H. Lefroy, C.B., K.C.M.G., F.R.S.

Colonel H. T. FitzHugh.	Major H. S. Clarke.
" E. Maitland.	Capt. S. C. Pratt.
Lt.-Col. C. E. Nairne.	" R. S. Watson.
" H. B. Maule.	" J. M. Alves.
" *Hon.* A. Stewart.	" J. R. J. Jocelyn.
Major J. H. Blackley.	Lieut. C. S. B. Parsons.
" R. C. Drysdale.	" R. A. Bannatine.

Lieut. F. J. A. Trench.

Major H. W. L. Hime, *Secretary and Treasurer.*

Major L. F. Perry, *Assistant Secretary.*

TRUSTEES:

General Sir J. St. George, K.C.B.
" Sir E. C. Warde, K.C.B.
D.-A.-G., R.A., for the time being.

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IV. The Annual Report having been read to the Meeting, it was proposed and carried :—

"That the Annual Report, as read, be adopted."

V. The Secretary was requested to open the sealed envelopes containing the names of the authors of Essays No. 6 and No. 5, to whom the gold and silver medals had been respectively adjudged, provided they did not exceed the prescribed limit of length. On doing so, Colonel H. A. Smyth and Lieut.-Colonel F. G. Baylay were found to be the successful competitors—this being the second occasion on which Colonel Smyth carried off the gold medal.

VI. It was proposed and carried to request the Deputy-Adjutant-General, R.A., to obtain the sanction of H.R.H. Field Marshal the Duke of Cambridge, Colonel of the Regiment, that the following be the subject for the Prize Essay for 1883 :—

"The best Organization of the *Personnel* of the British Artillery, having regard to the requirements of modern warfare."

VII. It was proposed and carried that in case of H.R.H.'s sanction being obtained, the length of the Prize Essay for 1883 be extended to 32 printed pages of the "R.A.I. Proceedings," in consequence of the complexity and importance of the subject.

VIII. It was proposed and carried that in case H.R.H.'s sanction cannot be obtained, the following be the subject of the Prize Essay for 1883 (with the usual limitation) :—

"The duties of the *Personnel* of a Battery of Field Artillery in action, from the time it takes up a given position until 'Cease Firing' is sounded."

(Signed) E. T. GAGE,
Major-General,
Chairman.

30 May, 1882.

APPENDIX D.

Presentations to the Library.

Russian Artillery Journal. Nos. 3 to 12, 1881, and Nos. 1 and 2, 1882	Russian Government.
Russian Small Arms Journal. Nos. 1 to 4, 1881, and No. 1, 1882	Russian Government.
Report of the Committee on the Working of the Staff College, March, 1880	Adjutant-General to the Forces.
Journal of the Royal United Service Institution	The Council.
The Archæological Journal, Nos. 148 to 153	The Council.

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APPENDIX A.

INCREASE AND DECREASE OF MEMBERS OF THE R.A. INSTITUTION

During the year ending 31 March, 1882.

Ranks.	31st March, 1881.	Increase.			Total increase.	Decrease.				Total decrease.	31st March, 1882.
		Promotions.	Retirement.	New members.		Promotions.	Retirement.	Withdrawal.	Death.		
EFFECTIVE LIST.											
Generals and Regimental Field Officers	514	54	—	—	54	—	21	4	4	29	539
Captains	368	82	—	—	82	54	4	3	4	65	385
Lieutenants	460	—	—	79	79	82	4	1	4	91	448
Paymasters	4	—	—	—	—	—	1	—	—	1	3
Quarter-Masters	4	—	—	—	—	—	1	—	—	1	3
Riding-Masters	1	—	—	—	—	—	—	—	—	—	1
Medical Officers	4	—	—	—	—	—	—	1	—	1	3
Veterinary Surgeons	3	—	—	—	—	—	—	—	—	—	3
RETIRED LIST.											
Generals and Regimental Field Officers	97	—	13	—	13	—	—	11	2	13	97
Captains	42	—	3	—	3	—	—	—	1	1	44
Lieutenants	11	—	2	—	2	—	—	—	—	—	13
Medical Officers	1	—	—	—	—	—	—	—	—	—	1
Chaplains	1	—	—	—	—	—	—	—	—	—	1
HONORARY MEMBERS.	48	—	—	—	—	—	—	3	—	3	45
Totals	1558	136	18	79	233	136	31	23	15	205	1586

APPENDIX B.

GENERAL ABSTRACT

OF THE

ACCOUNTS OF THE ROYAL ARTILLERY INSTITUTION,

From 1 April, 1881, to 31 March, 1882.

CASH ACCOUNT.

Payments.	£ s. d.	£ s. d.
A—Printing: Wages	118 16 8	
Paper and Materials	311 5 11	
Type and Furniture	22 8 3	
Wood Engraving	30 12 0	
Lithography	116 17 6	600 0 4
Photography		0 13 7
B—Classes		147 11 6
Lectures		6 2 0
Washing and Cleaning		23 13 10
C—Library, and Books for Sale		553 15 7
Museum		33 10 0
Instruments and Observatory		26 17 9
D—Carpentry: Wages	19 0 8	
Materials	47 1 0	66 1 8
Furniture and Repairs		4 14 5
Subscriptions to Societies and Refunded		8 3 0
E—Stationery		128 13 9
F—Postage and Parcels		114 12 6
Incidental Expenses		20 13 10
Wages to Clerks and Orderlies		142 5 1
G—W.O. Photographs and Lithographs		2 10 7
Gold Prize Medal		11 1 6
Fire Insurance		13 18 6
Cash in hand, 31 March, 1882: Of Secretary	3 4 0	
" Messrs. Cox & Co.	379 10 11	
" London & County Bk.	113 2 5	
" Army & Navy Co-op. Soc.	50 2 2	545 19 6
		£2450 18 11

Receipts.	£ s. d.	£ s. d.
Cash in hand, 31 March, 1881		395 12 7
A—Printing		73 9 11
B—Classes		36 2 9
C—Books and Binding		319 19 8
D—Carpentry		13 13 9
Subscriptions: Entrance... 1881-2	79 0 0	
Annual..... 1881-2	1247 19 6	
Arrears, paid in 1881-2 for 1871-2	0 10 0	
1872-3	0 10 0	
1873-4	0 10 0	
1874-5	0 10 0	
1875-6	1 0 0	
1876-7	1 10 0	
1877-8	3 16 0	
1878-9	7 4 0	
1879-80	12 0 0	
1880-1	30 5 0	
In advance... 1882-3	12 19 6	1397 14 0
E—Stationery sold		100 16 9
F—Postage and Parcels		43 12 2
G—W.O. Photographs and Lithographs		2 6 0
Dividends on Consols		67 11 4
		£2450 18 11

CAPITAL ACCOUNT.

Dr. Liabilities	£ s. d.	Assets.	£ s. d.	Cr. £ s. d.
Printing, Type, and Wood Engravings	48 15 0	Cash in hand, 31 March, 1882		545 19 6
Classes	16 16 0	£2300 Consols Stock, at 98¼		2284 13 4
Museum	7 10 0	Value of Stock: Printing Paper	39 11 0	
Books and Periodicals	30 1 0	Books for Sale	24 10 1	
Carpentry and Picture Framing	3 10 4	Stationery for Sale	9 11 7	93 12 8
Stationery	0 4 0	Chemicals in Laboratory	20 0 0	
Postage and Parcels	6 11 10	Owing by Members: Printing	18 19 5	
Army & Navy Stores, for Printing Lt.-Col. Cleaveland's Historical Notes	115 11 6	Classes	5 5 0	
		Books	103 6 0	
General Credit 31 March, 1882	3072 19 4	Carpentry	6 10 2	
		Subscriptions	168 13 6	
		Stationery	35 7 7	
		Postage and Parcels	38 2 8	
		W.O. Photos. & Lithos.	1 9 2	377 13 6
	£3301 19 0			£3301 19 0

Examined and found correct,

E. R. WETHERED, Major and Staff Paymr.

C. B. PIERS, Major, Paymaster, R.A.

Woolwich, 2 May, 1882.

APPENDIX C.

TABULAR ANALYSIS OF THE STATE OF THE R.A. INSTITUTION

From 1851 to 1882.

I. Year.	II. Number of Members	III. Income.	IV. Expenditure.	V. Amount in the Funds.	VI. Liabilities.	VII. Cash Balance.	VIII. Percentage of Members on Active List to total strength of Regiment.
		£	£	£	£	£	
1851–2	—	173	104	500	—	—	—
1852–3	—	214	136	500	—	—	—
1853–4	—	918*	978	500	—	—	—
1854–5	—	510	742	500	—	—	—
1855–6	714	580	368	500	—	212	96
1856–7	746	665	695	500	—	182	82
1857–8	?	588	647	1200	—	123	—
1858–9	794	640	709	1200	—	54	83
1859–60	863	690	733	1200	—	2	80
1860–1	986	740	733	700	—	9	82
1861–2	1037	800	807	700	—	2	84
1862–3	1108	936	838	1200	—	100	55†
1863–4	1167	977	1051	1200	249	26	59
1864–5	1213	987	996	1200	240	17	58
1865–6	1263	1030	1028	1200	301	19	60
1866–7	1315	1075	1088	1200	482	6	63
1867–8	1336	1097	1040	1200	316	61	65
1868–9	1377	1115	1167	1200	99	9	66
1869–70	1368	1122	1011	1361	73	120	66
1870–1	1386	1156	1373	1686	185	3	67
1871–2	1377	1174	1153	1686	91	24	65
1872–3	1385	1190	1118	1686	425	96	68
1873–4	1441	1247	908	1686	232	433	76‡
1874–5	1485	1313	1475	2000	111	271	78
1875–6	1498	1320	1079	2000	385	512	78
1876–7	1530	1328	1496	2000	100	344	80
1877–8	1553	1338	1439	2000	145	243	82
1878–9	1555	1367	1198	2000	105	412	83
1879–80	1565	1389	1169	2000	91	632	83
1880–1	1558	1396	1632	2300	102	395	81
1881–2	1536	1465	1314	2300	229	546	85‖

* About £700 of this year's income was subscribed for furnishing new building.

† The Indian Artilleries amalgamated in this year.

‡ Medical Officers removed in this year from the strength of Regiment.

‖ Veterinary Surgeons removed from the strength of the Regiment.

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Minutes of Proceedings of the Institution of Civil Engineers. Vols. 63–66	The Council.
Annual Report of the Instruction carried on at the School of Musketry, Hythe, during the Year ending 22nd April, 1881	Inspector-General of Musketry.
Journal of the Military Service Institution of the United States	The Council.
Journal of the United Service Institution of India. Nos. 46–50	The Council.
Regulations for the Supply of Clothing and Necessaries, 1881	D. A. General, R.A.
Report of the Siege Operations Committee on the Dungeness Experiments of 1879, with plates	
Regulations for the Commissariat and Transport Staff. Part I.	
Manual of Field Artillery Exercises, 1881	
Regulations for the Equipment of the Army, 1881	
Regulations for the Supply of Stores to an Army in the Field	
Report on the Dungeness Experiments of 1880 on Breaching	
Report of the Special Committee on Siege Operations	
Memorandum on the Dungeness Experiments of 1880 on Shrapnel and Case Fire from Siege Guns	
R. C. D. Lithographs, No. 53*a*, 56, 57	Secretary of State for War.
R. L. Lithographs, Nos. 101 to 129	
Anglo-Afghan War, 1879–80. Section 4	
Franco-German War, 1870–71, with Maps. Translated by Major F. C. H. Clarke, R.A. Sections 15 and 16	
Field Artillery Exercises, 1881	
Instructions for Cavalry. Von Schmidt	
Map showing the Sibi and Thal Chotiali Routes connecting the Khojak with the Indus Valley	
Equipment Regulations, 1881. Abridged Edition	
Instructions for Armourers in the Care of Small Arms and Bayonet Scabbards	
Narrative of Field Operations of Zulu War of 1879	
Siege and Assault of Denghil Tepe	
Sketch of the Ingogo Position	
Narrative of the Zulu War, with Maps, 1879	
Queen's Regulations and Orders for the Army, 1881	
Final Report of the Committee on Explosive Substances, 1881	Director of Artillery.
German Artillery. Précis of the most important occurrences noted during the Annual Practice of the Foot Artillery Regiments in the year 1879. Translated by Capt. W. M'Clintock, R.A.	

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Decisions on the Reports of the Foot Artillery Regiments relating to the construction of Batteries in 1879. Translated by Capt. W. M'Clintock, R.A.	Director of Artillery.
Final Report of the Special Committee on Range-Finders for Field and Coast Batteries.....	
German Artillery. Instruction for Siege Artillery Exercises. Berlin, 1880.....	
Notes on the International Exhibition on Electricity. Paris, 1881	
Treatise on Ammunition, 1881	
Paris Electrical Exhibition, 1881	
Report on Appliances connected with Artillery. By Captain H. Watkin, R.A.	
Report on an Explosion of Gunpowder in a Glazing House at Messrs. John Hall & Son's Gunpowder Factory at the Marsh, Faversham, on 11th December, 1880.....	Sec. of State for Home Dept.
Report on an Explosion of Gunpowder, &c., which occurred at Messrs. J. Hall & Sons at Eastwood, near Nottingham, on 14th January, 1881	
Report on an Explosion of Gunpowder at Blackbeck, Haverthwaite, Lancashire, on 19th March, 1881	
Annual Report of H.M. Inspectors of Explosives for the year 1880	
Report on an Explosion of Dynamite and Blasting Gelatine in the Minera Mine, near Wrexham, on 23rd March, 1881.....	
Report on Explosion in Messrs. Brocks' Firework Factory at South Norwood, on 24th May, 1881	
Report on an Explosion of Dynamite on the River Clyde, off Garvel Point, near Greenock, on 16th April, 1881	
Report on Explosion of Gunpowder at Gatebeck, near Kendal, on 21st July, 1881	
Report on the circumstances attending an explosion which occurred at a small Firework Factory at Nechell's Park Road, Birmingham	
Ordnance Notes, Washington, United States of America, Nos. 170, 175, 177-9, 183, and 185	S. V. Benêt, Chief of Ordnance.
Report on the State of the Militia of the Dominion of Canada, 1881	Inspector-General of Artillery, Kingston, Canada.
A Study of the Problem of Aerial Navigation. By W. Pole, Esq., F.R.S., &c.	The Author.
Local Government and Taxation in the United Kingdom. By J. W. Probyn.....	The Council of the Cobden Club.
Proserpina. Studies of Wayside Flowers	J. Ruskin, LL.D.
The Journal of the Iron and Steel Institute ...	The Council.
Insect Variety, its Propagation and Distribution	Captain J. J. Swinton, R.A.
The Unification of the Military Forces and Systems of the British Empire	The Author.
The Artillery Arm. Parts 1 and 2	

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Proceedings of the British National Veterinary Congress, 1881	The Congress.
Report of the Chapter of the Order of St. John of Jerusalem in England	Major F. Duncan, R.A.
The Southern Skies. A Lecture, delivered at Launcestown, 26 July, 1881, by H.E. Lieut.-General Sir J. H. Lefroy, C.B., K.C.M.G., &c.	The Author.
Revista Marittima, 1881 and 1882	Italian Government.
Narrative Sketches of the Conquest of Mysore	Lt.-Col. M. H. C. B. Steinman.
Deflection of Small Arm Projectiles	Lt. E. L. Zalinski, U.S. Artillery.
Map of the Northern part of the Regency of Tunis	Quartermaster-General.
Map of the Mediterranean Sea and Northern Africa	
Notes on the Russian Expedition against the Tekke Turcomans	
History of the Honourable Artillery Company. By Capt. G. A. Raikes, F.S.A., &c. 2 Vols. London, 1878	The Author.
Records of the First Regiment of Militia. By Capt. G. A. Raikes, F.S.A., &c. 1 Vol. London, 1876	
Netherlands Artillery Atlas. Plates 130, 132, 134, 45–7	Netherlands Government.
Questions and Answers on Minor Tactics for Officers attending Garrison Instruction at Rawal Pindi, 1875	Lieut.-Col. J. Haughton, R.A.
Reports of Artillery Experimental Practice at Kandahar	Colonel A. H. Murray, R.A.
Instruttione de Bombardieri, del Sig. Gabriel Busca, Milanese. 1 Vol. Turin, 1598	Capt. W. Graham, late Quartermaster, R.A.
Reglement Manœuvres des Batteries Atelées. 1 Vol. Paris, 1880	Capt. E. Walsh, R.A.
Collection of Curious Old Books on Artillery, &c.	R.A. Mess, Dublin.
Journal of Royal Geographical Society. Vol. 50, 1880	The Council.
Classified Catalogue of the Library of the Royal Geographical Society to December, 1870	
General Index to the Fourth Ten Volumes of the Journal of the Royal Geographical Society	
Smithsonian Report, 1879	The Council.
Smithsonian Contributions to Knowledge. Vol. 23	
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Memorial of Joseph Henry	
Tracts on Mechanics. By M. W. Crofton, F.R.S., and Major Kensington, R.A. 1 Vol. London, 1881	Professor M. W. Crofton, F.R.S.
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2 Sheets of Map of Turkestan. Plates 3 and 4	Royal Engineer Institute.
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APPENDIX E.

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Statistical Atlas. Parts 4 to 14.
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" " Zoology. Parts 10 to 16.
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The Creed of Science. By W. Graham. 1 Vol. London, 1881.
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Die Kriegfuhrung, 1882.
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" Birds of New Guinea. Part 12.
" Birds of Asia. Part 33.
Les Methodes de Guerre, par le Colonel Pierron.
La Guerre D'Orient, 1877–78. Paris, 1882.
Geographie Strategique (Essai), par le Colonel G. Sironi.
Der deutsch fransosiche Kreig, 1870–1. Berlin, 1881.
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Report of the Discipline and Management of the Military Prisons, 1880.
General Annual Return of the British Army for the Year 1800.
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Theorie Généralé du Mouvement Relatif des Axis de Figure et de Rotation Initiale des Projectiles de L'Artillerie.
England on the Defensive, or the Problem of Invasion. By Capt. J. T. Barrington. 1 Vol. London, 1881.
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APPENDIX F.

Presentations to the Museum.

27 Indian Butterflies and Moths	Lieut. Minchin, R.A.
A Burmese Dhao in Sheath	Lieut. E. G. Edwards, R.H.A.
9 Lead Coins of Andhras Dynasty of Southern India of about 4th Century, A.D.	Major-Gen. G. G. Pearse, R.A.
An Afghan Cartridge Pricker from Ali Musjid An Afghan Belt from Jellalabad.....	Captain E. Walsh, R.A.

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11 Birds from Demerara	Mr. H. Whitely, Junr.
1 Bird from Brazil	
2 Colorado Beetles	Lieut.-Col. W. H. Noble, R.A.
An Afghan Knife	Captain S. G. Smyth, R.A.
Case of Jamaica Moths and Butterflies	Major W. O. Carlile, R.A.
Specimen of Saw Fish	Captain F. Richmond, R.A.
Water Color Sketch. Detachment of Bengal Horse Artillery	General G. Campbell, C.B.
Two Attestation Papers, dated respectively 1797 and 1812	Captain K. Stephenson, R.H.A.
A Combined Time and Percussion Fuze, proposed by Major G. B. Macdonell, R.A.	Major G. B. Macdonell, R.A.

APPENDIX G.

List of Papers published in the "Proceedings" during the Year.

The Organization and Employment of Garrison Artillery. Translated by a Member of the R.A. Institution.

Zaimukht Expedition. By Captain G. T. Carré, R.A.

Notes on the Laying of Guns by means of a Telescope. Translated from the French by Captain E. Walsh, R.A.

Description of a Special Ammunition Box. By Captain A. F. Fletcher, R.A.

Précis of Contents of the "Organ, &c.," Part 4, Vol. XXI. Translated by Lieut. J. M. Grierson, R.A.

Extracts from the "Revue d'Artillerie," November, 1880. Translated by Captain A. E. Turner, R.H.A.

Contents of the "Mittheilungen, &c.," 10th and 11th Parts, 1880. Translated by Captain G. C. Wynne, R.A.

Note on the Elementary Squad Drill in the Swiss Army. By Captain C. S. Graham, R.A.

Trajectories of the 9-pr., 13-pr., and 16-pr. M. L. R. Guns. By Lieut. P. A. MacMahon, R.A.

Infantry Fire in Fortress Warfare. Translated by Lieut. R. M. Bond, R.A.

German Imperial Manœuvres, 1880. By Captain A. E. Turner, R.H.A.

Defence of Ekowe. By Lieut. W. N. Lloyd, R.H.A.

On Improved Shape for Moulding Gunpowder. By Lt.-Col. M. Tweedie, R.A.

Addendum to the Drill Regulations of the Foot Artillery. Berlin, 1880.

Notes from "Report on Experiments with Armour-piercing Projectiles up to 9-inch calibre." By Captain J. P. Cundill, R.A.

Translations of Reports of Experiments, &c., with Armour-piercing Projectiles, carried out in Russia and Holland during the last two years. From the "Revue d'Artillerie." By Captain W. M'Clintock, R.A.

Dutch Trials of Competitive Projectiles. By Lieut.-Col. Le Fer Taylor, R.A.

Practice with the 25^{mm} (1-in.) Nordenfelt Machine Gun, on H. Grüson's Practice Ground at Bŭckăn, on 22nd December, 1879. By Captain E. Bainbridge, R.A.

Description of the 1-in. Torpedo Battery Gun. By Captain E. Bainbridge, R.A.

Note on the Service of the Artillery at Maiwand, 27th July, 1880. By Captain N. P. Fowell, R.A.

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Résumé of an account of Comparative Trials of the Nordenfelt Mitrailleuse and the Hotchkiss Revolver Gun, carried out in England, Italy, Denmark, Russia, and France. From the "Revue d'Artillerie," February, 1881. By Captain A. E. Turner, R.H.A.

Austria. { Trial of a Repeating Rifle. / Use of Dynamoge. } Translated by Captain A. E. Turner, R.H.A.

Extracts from the Diary of a Russian Artilleryman in the Shipka Pass, 1877. From the Russian. By Lieut. J. M. Grierson, R.A.

The Artillery and Engineer Journal. From the Italian. By Captain A. E. Turner, R.H.A.

On Fixing Positions by the More Simple Astronomical Observations, for the use of R.A. Officers engaged in Exploration. By Major E. S. Gordon, R.A.

The Equipment of Field Artillery. (The Gold Medal Prize Essay, 1881). By Captain J. R. J. Jocelyn, R.A.

Abstract of the Proceedings of the Forty-Fourth Annual General Meeting of the Royal Artillery Institution.

On the Motion of a Projectile in a Resisting Medium. By A. G. Greenhill, M.A., Professor of Mathematics to the Advanced Class of Artillery Officers.

Description of a Veterinary Field Companion. By Lieut. J. Hotham, R.H.A.

Extracts from the "Russian Small Arm Magazine," No. 3, 1880. By Lieut. J. Wolfe Murray, R.A.

Observations by a Subaltern on a paper entitled "Subaltern Officers." By Lieut. R. F. Johnson, R.A.

Complete List of Personal and Official Equipment for Special Service. By Colonel F. E. Cox, R.E.

List of Necessaries and Luxuries for Campaigning and Exploring. By Captain T. Fraser, R.E.

The Effect of Shell on Mud Walls. By Brig.-General Denis-de-Vitre, R.A.

Remarks on the Weldon Range Finder. By Lieut. A. H. Russell, U.S.A.

Extracts from the Russian Artillery Journal, November, 1880. Translated by Lieut. J. M. Grierson, R.A.

Tactics of the Three Arms. By Captain T. J. Roch, R.A.

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Extracts from the "Organ der Militar Wissenschaftlichen-Vereine. Translated by Lieut. J. M. Grierson, R.A.

Notes on the Austrian Field Artillery Service Practice, as introduced in 1872. By Colonel W. H. Goodenough, R.A.

Note on the Prussian Mode of Indirect Laying of Guns. By Major Van Straubenzee, R.A.

Extracts from the "Memorial de Artilleria." Translated by Captain J. C. Dalton, R.A.

The French in Africa, from the Deutsche Heeres-Zeitung, 20th August, 1881. By Capt. T. J. Roch, R.A.

Experiments carried out by Herr Krupp at Meppen. By Major C. H. Fairfax Ellis, R.A.

Short description of Small Stone-Wall Fort thrown up for two 7-pr. R. M. L. Jointed Guns of No. 1 Battery, 8th Brigade, (Mountain Battery) at Camp Thull, during the Afghan War of 1879–80. By Lieut. T. V. W. Phillips, R.A.

The Training of "Pointeurs" for Artillery: from the French. By Lieut. H. C. Dunlop, R.A.

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The Battles of Laing's Nek and Ingogo, with Brief Notes on the 9-pr. of 6 cwt., and General Equipment. By Lieut. C. S. B. Parsons, R.H.A.

Rough Notes on the Kabul-Kandahar March of August, 1880. By Lieut.-Col. G. T. Pretyman, R.A.

Siege of Potchefstroom. By Lieut. H. M. L. Rundle, R.A.

On the Motion of a Projectile in a Resisting Medium, (continued from p. 598, Vol. XI.) By A. G. Greenhill, M.A., Professor of Mathematics to the Advanced Class of Artillery Officers.

Note on the Armament of Drivers. By Lieut. E. A. Lambart. R.A.

The Attack of Armour-clad Vessels by Artillery. A Lecture delivered at the R.A. Institution, on 19th October, 1881, by Capt. C. Orde Browne, Late Royal Artillery.

Russian Remounts. A Review. By Captain T. J. Roch, R.A.

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NOTES

ON THE

HISTORY OF GAS-CHECKS,

BY

MAJOR G. W. HAWKINS, R.A.

THE earlier Woolwich guns were extremely costly, both in the first instance, and on account of the very few rounds which each gun could fire without being re-tubed; an operation of not much less magnitude than that of making a new gun.

This shortness of life was due to "scoring,"—the erosion of the steel tube over the seat of the shot caused by the escape of the heated powder-gas before the shot begins to move. This scoring, which is one of the defects of any system of rifling allowing windage, had not previously been noticed, because in the Armstrong B.L. system there was no windage, and in the smooth-bores the spherical shot began to move before the escape of the gas over the top of it was strong enough to harm the bore; and, besides, the importance of the evil increases with the calibre of the gun.

It now became a very serious matter, thus: a 7-inch gun became unserviceable after firing 500 rounds, during which it was re-vented five times, and it was necessary to find some means of reducing the extent of the erosion. The first remedy suggested was to plug up the vent, turn the gun upside down, and re-vent it on the other side. This expedient nearly doubled the life of the gun; but it entailed sending it to Woolwich, and was laborious and costly, while the evil of "scoring" was in no way diminished. Attention was then turned to the production of a wad which should prevent this action.

So early as January, 1866, two wads having this object were proposed by Colonel Wray, C.B., R.A. These wads were made of wood, faced with millboard, and notched so as to facilitate breaking up, and having a conical hole in the centre into which fitted a hard wood wedge. The edge of one wad was made of rope, that of the other of lead, and it was hoped that these edges would be forced into the grooves on the splitting up of the wad by the action of the central wedge; but on trial they were not so successful as was anticipated. Report of Committee on prevention of scoring, 4/4/71. 1866.

In July, Captain Noble, R.A., suggested an inverse method of ascertaining the best material for a wad to prevent scoring, by observing

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the velocities of the projectiles fired from the same gun with the same charge but with different wads: and showing that the wad which sealed the windage most effectually would cause the powder to impart the greatest velocity to the projectile.

1867. Ultimately a trial was made by the Ordnance Select Committee upon the inverse method, recommended by Captain Noble, of several kinds of wads; but the velocities with all the wads, except one of *papier-maché*, were lower than when none at all was used. A second trial was made, in which recovered common shell, with their studs somewhat worn down so as to increase the windage, were used; and a decided increase of velocity was obtained by the use of the *papier maché* wad, of a flat tin plate, and of the Bolton wad, which was then for the first time introduced.

1868. After some further trials, the adoption of the *papier maché* wad with projections to fit the grooves of the gun was recommended; but, on the representation of Rear-Admiral Key that the projections would
17/7/68. retard loading, patterns without projections were sealed, though those having them appear to have been most extensively used.

18/7/68. Shortly after, Major Bolton offered to supply wads made from 75 per cent. of old rags, known as "tammies," and 25 per cent. of old tarred rope, formed in a mould, and coated with a waterproof varnish when dry, at 20 per cent. less than the cost of those made in the Royal Laboratory. Accordingly, wads of Major Bolton's pattern were sealed. Several comparative trials were made between the two wads
1869. without eliciting that one prevented scoring much more than the other; but a new danger was discovered in the burning fragments of the Bolton wad, which were occasionally blown back through the ports on to the deck of the ship from which they had been fired.

1870. This inflammability was at first referred to the waterproof varnish with which the wads were covered; and trial was made of a fireproof cement, with the object of making them uninflammable, but without success, until, in November, Major Bolton succeeded in making them of a material that would not take fire, consisting of a mixture of animal fibre, refuse wood, and silk.

6/3/71. However, all the wads yet introduced were so inefficient, or, as one report says, so "perfectly useless" for the prevention of scoring that the Superintendent, Royal Gun Factory, drew attention to the matter "as a question of economy," suggested a fresh trial of the tin-plate wad, and submitted a tracing of the first "gas-check."

4/4/71. A Committee was appointed, and reported on the whole matter. They recommended further trials of three 7-inch guns:—

1. With a Bolton wad with projections.
2. With a gas-check of a pattern proposed by themselves.
3. Without any wad.

24/8/71. The gas-check recommended took the form of a tin disc or cup; but it was found unsuitable in consequence of its tendency to fly about in front of the gun.

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The result of the experiments clearly established the fact that neither the Bolton wad, nor any one of several other kinds made from various materials, such as cowhide, &c., was of any use in diminishing scoring; and, at the same time, it was discovered that the larger charges of P. powder, which were then being introduced, were even more destructive to the bore from their erosive effect than the smaller equivalent charges of L.G. or R.L.G. Report of Committee, 27/7/72.

The Committee reported that the evil was not likely to be obviated by any nature of wad; but that the desired result might be arrived at by some suitable form of gas-check, "the success of which would, in a great measure, depend upon the security with which it would attach itself to the base of the shot on the explosion of the charge, and that one which would become detached during flight or fly to pieces would be inadmissible."

Several forms of gas-checks were proposed and experimented with. They were of various forms and materials, but generally of a soft white metal, though Major Maitland, R.A., proposed the first copper gas-check, which was on the same principle as the tin cup of an Armstrong B.L. gun. 22/5/73. 2/12/72.

Major Bolton suggested a wad made of loam or clay, on the principle on which those materials are used to stop the leak in a steam-pipe, and mentioned many advantages which would be gained by its adoption; but after trial the Committee reported that "no material softer than copper will stand the rush of gas through the windage on the explosion of the charge." Moreover, they considered "that there were grave practical objections to the adoption of an article of store which must be made as required, and which would become useless if three days old." 1873.

In February, Sir William Armstrong & Co. proposed a polygrooved gun with increasing twist, to take a special projectile fitted with a soft metal ring, which was to seal the windage, and, at the same time, to impart rotation to the shell. This projectile was slightly coned at the base to take a ring of "pot-metal" (a mixture of copper and lead), below which was placed a steel ring, which on the explosion of the charge was forced forward and drove the pot-metal ring up the cone, thus expanding it into the grooves. The front of the projectile was fitted with a brass ring, to prevent the iron coming in contact with the bore. The experiments with this system were fairly successful, but when a harder alloy was tried the rings came off in flight, and a modification of it applied to service projectiles gave an inferior result. 10/2/74.

In the course of these experiments, it was early discovered that an efficient gas-check increased both the range and the accuracy of service projectiles, and that rotation could be imparted to a projectile by means of the gas-check alone without the assistance of studs. Towards the close of the year, the experiments were confined, on the principle of the survival of the fittest to competitive trials, between the forms of gas-check proposed by Major Maitland, R.A., and Major Lyon, R.A. Both were of copper, with projections to fit the grooves. That of the former was automatic; but required the formation of an undercut 8/5/74. Major Maitland's form.

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annular ring on the base of the projectile, to which it attached itself on discharge, while that of Major Lyon's was attached, before loading, by a screw-nut and plug.

Major Lyon.

Screw on base plug.

And now a difficulty arose about the screw on the base plug. With the usual right-handed thread the plug was liable to become unscrewed during flight. To obviate this, some of the earlier base plugs were made hollow at the end remote from the nut, this end being filled with a conical plug, called a hammer, which was set back on the shock of discharge, and so expanded the end of the plug as to fix it firmly in its bush, and effectually to prevent its becoming unscrewed.

However, it was eventually discovered that a simpler method of securing the plug was to make the screw left-handed; and accordingly all the service plugs have been so threaded.

Projections discontinued 11/9/74.

The difficulty of loading a projectile fitted with a gas-check having projections to fit the grooves induced Major Lyon to propose their omission.

10/6/75.

In June of this year a printed report was issued by the Committee on Explosives, to whom the question had been referred, showing that the use of gas-checks gave to the projectiles of the 38-ton gun an additional velocity equivalent to that which would be obtained by lengthening the bore three calibres, while causing no material increase of pressure in the gun, and that, at the same time, the gas-checks of the pattern then under trial materially diminished scoring.

21/1/75.

Goold-Adams.

Meanwhile a modification of Major Maitland's gas-check had been proposed by Lieutenant Goold-Adams, R.A. The essential difference was that whereas in the original proposal, the undercut ring was cast on the base of the projectile, in the modification, it formed part of a wrought-iron plug screwed into the base, while, to prevent the plug coming unscrewed, a hole was drilled in the thread parallel to the axis of the plug, and extending both into the plug and into the metal of the shell, and fitted with a copper plug. In another form, proposed by Lieutenant Goold-Adams, the wrought-iron disc having the projection on it was distinct from the plug, which was of gun-metal, and had a conical head to secure the disc to the shell.

Jones.

About the same time, Captain C. Jones, R.A., proposed an automatic gas-check which should attach itself by means of an undercut groove in the circular head of a plug similar to that used with the Lyon pattern, but having a much larger head. This means of attachment is very similar to that now employed with studded projectiles and the Elswick Ordnance Company's gas-check. Both these patterns had projections to take the grooves.

1876.

Early in the year experiments were made with the Goold-Adams' pattern, and a slight modification of it proposed by the Superintendent Royal Laboratory. This consisted essentially in increasing the concavity of the check near the circumference, and hollowing out the back of the projections.

Under this form, which appears for some time to have been called indifferently "Goold-Adams" or "R.L.," this pattern was subjected to extensive trials, and was on the point of being adopted into the Service.

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About this time, some experiments were made with gas-checks made of brass and of gun-metal; but, though some of both kinds stood well, they could not be depended upon to adhere to the projectile throughout its flight, and copper was recognised as the only thoroughly trustworthy material. Brass and gun-metal.

So far the experiments with gas-checks had been fairly successful, and it was proposed to apply them to field and siege guns, when, for the first time, it was discovered that the range of R.M.L. howitzers firing gas-checks with projections was *diminished;* and this phenomenon, which is now known to admit of very simple explanation, caused a considerable amount of wonder at the time, and a gas-check without projections was recommended for use in future experiments with these pieces of ordnance. Howitzers.

The advantages claimed for the automatic check were stated by the Committee to be:— Advantages of automatic form. 30/8/76.

1. That it is not liable to injury in the Naval shot racks, or in the operation of loading.

2. That no preparation of the projectile before loading is necessary.

3. That projections to fit the grooves can be employed with less interference with the facility of loading, while the only objection is that it may be loaded with the wrong side next the projectile; but the Committee considered this of the less importance, as the gas-check is painted black on one side only, to guard, as far as possible, against this mistake.

In January, the Committee issued their final report, embodying all their *ad interim* recommendations, in which they stated:— 27/1/77.

I. That a gas-check could be produced which would adhere to the projectile throughout its flight, and the use of which ensured a considerable gain in length of range and accuracy of shooting.

II. That the reduction of scoring from the use of gas-checks was highly satisfactory, and that the life of the steel tube had been materially increased; but that, to render them thoroughly efficient, projections to fit the grooves were necessary.

III. That the plan of attached gas-checks proposed by Major Lyon is cheaper than that proposed by Major Maitland, and has the advantage of being applicable to existing projectiles; but it requires to be fitted on to the base of the projectiles before loading, instead of attaching itself automatically, and that, to facilitate loading, it became necessary to remove the projections fitting the grooves; notwithstanding which, the gas appeared to expand the metal into the grooves, though not enough to completely stop all scoring in them.

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IV. Some of the Goold-Adams' automatic gas-checks having been tried on board H.M.S. "Glatton" for stowage, facility of loading, &c., the Committee considered the results favourable to its adoption, and recommended that patterns should be prepared for sealing suitable to every gun in the service, with projections for guns of 38 tons and upwards, without for smaller natures.

V. That Palliser and common shells of future manufacture should be prepared to take gas-check plugs, but that, in shrapnel shell, these fittings should be confined to those of 25 tons and upwards.

VI. That the use of gas-checks with 7-inch and 8-inch guns should be abandoned, as comparatively few existing projectiles could be fitted to take them, and as the prevention of scoring in these guns is a matter of minor importance.

Result. The recommendation to prepare patterns of the Goold-Adams' gas-check for sealing was approved; but, as we shall see, the whole question was soon after re-opened, and thus no action was taken upon the matter.

Application to howitzers. A considerable difficulty now arose in the application of gas-checks to projectiles fired from R.M.L. howitzers; because, when the material was made sufficiently strong to withstand the larger charges, it did not expand properly when the smaller ones were used, and, if made sufficiently thin for the latter, it was blown to pieces by the larger charge. Several suggestions were made with a view of surmounting this difficulty, such as that the check should be made of pewter or gutta-percha, and trials were made of a cup-shaped and of a ring gas-check, as well as a special one made of pewter between two thin sheets of copper, and having projections to fit the grooves.

Cause of loss of range. During these experiments, the cause of the reduction in range, when gas-checks having projections were used with M.L. howitzers, was discovered to be the increased air-space of the charge due to the projections being abruptly stopped at the end of the rifling. As the accuracy was more than trebled (*sic*), and the range could be recovered by using a larger charge, this was not considered of much importance; but fire-holes were recommended in the gas-check to insure the ignition of M.L. time fuzes.

6/2/78. The result of all these trials was the adoption for the 6·3-inch howitzer of a saucer-shaped gas-check, stamped from No. 8 B.W.G. sheet-copper, having projections on its edges to take the grooves, and on its face to fit into radial grooves in the base of the shell, so as to impart rotation to the latter. In general construction, this is very similar to a rotating gas-check proposed by Captain Blakely many years ago, and experimented with as far back as 1865.

In the service pattern five fire-holes are bored through the copper to allow of the passage of the flame to the fuze. By adopting this

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construction, it was possible to use a material strong enough to withstand the explosion of the larger charges, while the absence of expansion with the smaller ones was compensated by the projections on the edge.

For the 8-inch howitzer of 46 cwt. was adopted a Lyon gas-check, 15/4/78.
similar to that which had now become the service pattern, but thinner, to allow of its being more easily expanded, and having four projections to fill the grooves, and eight fire-holes for the passage of the flame. On the same day was approved a battering-shell for the 64-pr. gun, and a plain gas-check for it without projections or fire-holes, and, to simplify manufacture, the same plug but cut to different lengths was adopted for this and for both howitzers.

In the meantime, more extended trials having established its general 16/3/78.
suitability for heavy guns, the plain Lyon gas-check for Palliser and common shells was sealed for all natures of heavy R.M.L. guns from the 9-inch to the 12·5-inch. To distinguish it from the later pattern this was afterwards called Mark I. It may be known by its plain edge, and by being fixed immovably to the shell when the nut is screwed home. The same order extended its use to the 7-inch double-shell; but stated in a footnote that the pattern of that nature was not then sealed, and it was finally declared obsolete in February, 1882.

For the 40-pr. common and shrapnel, a pattern having three projec- 16/5/78.
tions and six fire-holes was introduced; and, at the same time, a plug which was made applicable to it and to all smaller natures of studded projectiles; but, though experiments were made with gas-checks in the 16-pr., it has not been considered necessary to extend their use to that calibre.

Many experiments were made about this time with a view of 31/12/78.
adapting gas-checks to heavy shrapnel; but it was found that when firing full charges they were rammed up into the unrifled part of the gun, and consequently were not properly expanded so as to fill the grooves. The greater radius with which the base was cast also created a difficulty; and the general result was that they were considered inapplicable for shrapnel for these natures, except for the 38-ton gun, for which the shell could in the first instance be made of a suitable form.

The introduction of gas-checks necessitated the preparation of fresh 1879.
range-tables. In doing this, some bad shooting occurred, which was at first referred to the loading of the check past the bottom of the rifling; but an experiment, made with a 9-inch gun fired with a 3/6/79.
battering charge of P. powder, when the check did not pass the end of the grooves, and a full charge of R.L.G. when it did, satisfactorily proved by the better shooting with the smaller charge that the cause of the inferior practice had not been accurately determined.

This re-opened the whole question, and further experiments showed that projections on the gas-checks to fit the grooves were rendered necessary by the introduction of the slower burning powders, which did not expand the copper into the grooves so rapidly or regularly as the more "brutal" blow of the R.L.G., and that consequently a certain

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quantity of gas passed the check, whereby the projectile was rendered unsteady, and scoring was not prevented.

7/5/80. Pending the settlement of this question, the manufacture of the plain pattern was discontinued. As the trials conducted in the Spring of this year with the patterns having projections, seemed to show that they increased the difficulty of loading, especially with the heavier natures of guns, the Committee on the Working of Heavy Guns recommended the adoption of the modified Goold-Adams' form of gas-check for all studded projectiles for heavy guns; but the preliminary practice was not satisfactory, some of the gas-checks becoming detached in

3/12/80. flight, and others having their rims much torn; and the Committee finally reported that "The experiments with the Goold-Adams' form of automatic gas-check, though promising, have not been sufficiently successful to warrant its introduction into the Service without further

15/7/80. trials." The Lyon ribbed gas-checks were then reverted to, and further experiments were conducted with them. It had been previously found that the loading was much facilitated if the gas-check was free to revolve on the plug; and to admit of this, while retaining the original plug, a circular shoulder was turned on the nut, and the hollow in the centre of the check made sufficiently large to fit over this; so that the nut pressing against the base of the shell was no impediment to the free revolution of the check which turned upon the shoulder of the nut instead of upon the plug. But this arrangement gave too much play, and the check was liable to be gripped by the nut and fastened on eccentrically; and so the original nut was retained, and a brass washer of slightly greater thickness than the gas-check, placed between the nut and the shell, but was abandoned on account of the objection to an additional store. Mark I. plugs were then re-cast; and Mark II. have a plain shoulder which prevents the nut, which was at the same time made shallower, from being screwed down

8/9/80. so as to grip the gas-check; and a pattern of Mark II. with all these alterations was adopted for the 9-inch common and Palliser shells.

During these experiments, it was found that when once erosion had decidedly commenced in a gun no gas-check was of much use in preventing its extension; in fact, the more perfect it is, the more rapidly will the damage increase, since the gas has a smaller escape-hole, and will consequently move with greater velocity.

Rotating Gas-checks.

The question of imparting rotation to the projectile by means of the gas-check alone without the assistance of studs was early brought forward by Sir William Armstrong, who tried a 9-inch polygrooved gun firing projectiles on that system in 1874, and supplied studless projectiles for a service 9-inch gun in 1876, and again in 1878. The general result was, that there was no practical difference in the shooting of these projectiles compared with the service ones when fitted with gas-checks; but an advantage was gained in strength of shell by omitting the stud-holes, and the manufacture of the studless

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was slightly more economical. About this time, too, some trouble was occasioned by the wedging action of the service gas-check in the 80-ton gun, and further trials of the rotating form were therefore 22/8/78. decided on.

The E.O.C. checks were "automatic" as well as "rotating," but during the trials, they were fastened on to the shells by "nicking" with a chisel and hammer before the latter were loaded; and, as some difficulty occurred during this operation, the ribs were in one experiment filed off. The results of these trials were so promising that further experiments were carried out, both with the 9-inch and 38-ton guns, and finally it was ordered that the manufacture of studded projectiles should cease. Both ribbed and plain gas-checks were tried, 1/3/79. and the necessity for the projection on the checks, in the case of heavy guns, at least, fully demonstrated.

In October, 1880, a rotating gas-check of the E.O.C. pattern without 16/10/80. projections was approved for the 7-pr. jointed gun; and, in December, 3/12/80. the recommendations of the Heavy Gun Committee on the subject of gas-checks were submitted, though, owing to the delay in printing, the Report itself did not appear till two months later. 16/2/81.

The recommendations were:—

1. *For studded projectiles provisionally.*—The introduction of the Lyon gas-check, Mark II., with projections, and arranged to rotate freely on its plug.

2. *For studded projectiles after further experiments.*—As a projectile with an attached gas-check is more difficult to load than one with an automatic one, which difficulty increases with the calibre, and becomes of serious consequence in calibres of 10-inch and upwards, the Committee recommend that when an automatic gas-check of trustworthy pattern is secured, it should supersede all others for studded projectiles.

3. *For projectiles of future manufacture.*—The projectiles for 9-inch guns, and upwards, to be studless and fitted with the E.O.C. pattern automatic rotating gas-check.

Results.

Mark II. gas-check nut and plug which, as we have seen, had been 3/3/81. already adopted for the 9-inch gun were extended to all heavy guns, from the 10-inch to 12·5-inch inclusive, and the E.O.C. rotating with projections, already adopted for the 8-inch howitzer of 70 cwt., was 17/11/80. approved for the 6·6-inch howitzer and for the 80-ton gun. 30/3/81.

For the 13-pr. was adopted the same pattern as had already been 14/5/81. introduced for the 7-pr., and the use of the heavy gun pattern was extended to all natures from the 10-inch to the 12·5-inch, the projectiles for which are now all made of the studless pattern, and the word "rotating" superseded in the official designation by "automatic." 6/2/82.

Thus, by the early part of the current year, two of the Committee's

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recommendations had been adopted, and it only remained to secure an efficient automatic gas-check for the existing studded shell, which has since been done by fastening on to the base of the shell a wrought-iron projection, similar in shape to that cast on the base of studless projectiles, by a gun-metal plug with conical head. The shell thus
3/3/82. prepared takes the same E.O.C. gas-check as the new studless one. Departmental patterns of projectiles so altered, from 9-inch to 12-inch of 35 tons, have been deposited in the Model Room; but many gas-checks of Mark II. pattern continue to be manufactured for issue to the Royal Navy, and are made use of in many existing ships, the fittings of which are not suitable for any other form.

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A TOUR

OF THE

FRANCO-GERMAN BATTLE FIELDS.

BY

LIEUTENANT F. G. STONE, R.A.

A BRIEF account of the best way to visit the principal Franco-German battle fields may be acceptable to many who wish to study the tactics of the war on the ground, but who are deterred by not knowing how to set about it.

Battle fields.

The battle fields which it is proposed to include are those of Sedan, Colombey, Nouilly, Noiseville, Vionville, Mars-la-Tour, Gravelotte, St. Privat, Spicheren, Wörth, and Weissenburg.

General scheme.

The approximate distance to be walked on each day averages 20 miles: this distance may, however, be shortened at the pleasure of the individual; and if only a general knowledge of the field, together with a close inspection of but a few points of very special interest be all that is desired, it will be found that in the majority of cases this object can be attained without any undue strain on the pedestrian capacity. The scheme for each day will, however, be given, on the supposition that a complete and comprehensive knowledge of the tactics of each battle field is the object in view: it will be easy for each individual to take, or to leave, as much as may appear desirable to him.

Works of reference and maps.

For a thorough appreciation of the subject, it is absolutely necessary to be provided with the official maps of each battle field, and also the German official account of the operations; the latter, translated by Major Clarke, R.A., is published in sections, each section comprising a particular group of events. The German official account being very detailed, involves a considerable amount of reading; and it is recommended that this should be carefully gone through with the maps before starting. A good general account of the operations up to and including Sedan, will be found in the "War of 1870–71," translated from the German by Captain Ellis: the perusal of this work will be of much assistance to those who do not wish to go much into detail: but for a careful tactical study, the German official account is indispensable, and is of special value on account of its freedom from bias, thus leaving the reader to draw his own inferences from the impartial statement of facts.

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Owing to the amount of cross-country work to be performed, and the slippery nature of the bye-roads in wet weather, a pair of shooting boots and leggings are strongly recommended. Travelling second class on the German railways is generally feasible without much discomfort, but it is not recommended on French lines.

It is proposed to start from Sedan, working towards the Rhine, thus reversing the order of operations. It will, however, be found that this is by far the most convenient plan; and as the study is merely one of battle fields and not of Military History, the order in which the battles are treated will not affect the question.

1st day: Sedan. The "Hotel de la Croix d'Or" at Sedan is strongly recommended. Walk from the Hotel *via* Balan to Bazeilles—important example of village defence; go through the Park of Monvillers Chateau; ascend heights to left of road at La Moncelle, noticing French position on height marked (780) on map; notice from here the position in the Fond de Givonne, &c. Cross the Givonne river at Daigny, ascending height (1023) between Givonne and Villers Cernay, recross valley at Givonne, walk along French position to (920), past the Calvaire d'Illy, along the ridge to Floing; note position of Prussian Artillery near Villette, enfilading and taking in reverse the French position from Floing to Illy. Lunch may be obtained at Floing.

Ascend height (812) north of Floing; study Prussian advance and Artillery position; thence through St. Menges and along road through defile on north bank of Meuse: note defensive advantages of this defile, through which the Prussians were allowed to advance unopposed. Back to Sedan by Villette and Torcy.

2nd day: Sedan to Metz. Sedan has ceased to be a Fortress, and the fortifications are utterly dismantled. Verdun has replaced it as a frontier stronghold.

From Sedan to Metz by rail. "Hotel de l'Europe" moderate and very comfortable. Ascend to top of Cathedral, with map; a capital view of the surrounding country is obtained.

3rd day: Battle of Colombey-Nouilly. From Metz by Grigy to Mercy le Haut; remark position of Fort Queuleu *en passant*; on to Ars Laquenexy, Aubigny, Coincy, Montoy—lunch at Brewery—Noiseville, Nouilly, Mey, Vantoux, Bellecroix; cross the heights to Colombey, noting the French position along the avenue of yew trees; back again by Colombey to Borny Heights, noticing Fort les Bordes. A little extra walking will include the Field of Noiseville. After leaving this place, cross the valley to Servigny, thence by Failly and Villers l'Orme to Nouilly.

This day's work may be much lightened by driving direct to Ars Laquenexy, without losing anything of great importance.

4th day: Battle of Vionville-Mars-la-Tour. Train to Novéant about 9 a.m. 'Bus to Gorze (there is no 'bus to meet the 11 a.m. train); walk due north to Maison Blanche—the "col" upon which this house is situated was the scene of desperate fighting: turn sharp to the left, across ravine, ascend height (989) to French Artillery position; thence walk south-west to Prussian Artillery position near the monument; turn to the north and walk along position to Flavigny, noting Prussian Artillery position to the left on height (923): thence by Vionville to Mars-la-Tour, where lunch may be obtained; note here the ground over which the famous Cavalry charge

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took place, and the advance of the 38th Brigade to La Greyère farm, &c.; work up to the north of Tronville Copses, and by Roman road across French Artillery position (980) to Rezonville; note here the ground over which the gallant charge of Von Bredow's Cavalry took place. Proceed to Gravelotte, and examine position for next day; continue along the road to Moulins les Metz, where train or tramcar will finish the journey into Metz.

5th day: Battle of Gravelotte-St. Privat.

Train from Metz to Amanvillers; walk to St. Privat and Roncourt, back to St. Privat, thence to St. Marie aux Chênes; noticing the ground over which the Prussian Guard advanced on the left of the road. Lunch at St. Marie aux Chênes. Proceed to Verneville; follow Prussian advance on Amanvillers, noticing German Artillery positions; thence by Montigny la Grange to Leipsic, Moscou, and St. Hubert; noticing the French position in the Bois des Genivaux. Home by Moulins les Metz, as on the previous day.

6th day: Spicheren.

Train from Metz to Saarbrücken; notice the Iron Works after passing Forbach in the train. Ascend the Parade Ground at Saarbrücken, cross the valley to the Rotherberg, thence in a westerly direction to Golden Brewery—lunch. Examine Stiring Wendel and heights above. Take train at Forbach to Saarbrücken, where baggage can be picked up.

Railway arrangements.

Book heavy baggage from Metz to Reichshoffen; take ticket for self to Saarbrücken; leave light baggage in charge of guard at this station; tour of Spicheren battle field; take ticket at Forbach for Reichshoffen, receiving light baggage at Saarbrücken *en route*.

Arrival at Reichshoffen

After crossing the Vosges, Reichshoffen is reached. There is an Inn on the opposite side of the road to the station; it is primitive, but fairly comfortable, and the bed-rooms are good and clean: all the members of the family speak English.

7th day: Battle of Wörth.

Walk to Froschwiller, noticing the position of the French 1st Division on the left of the road; turn north-east to Oil Mill, thence to Wörth; cross to east bank of the stream, traverse German Artillery position, and continue to Gunstett—lunch: examine position of Mill flanking the valley to the north. Follow road to Morsbronn, Albrechtshauserhof, along foot of hills to (554), thence ascend to Elsasshausen, and by Froschwiller home.

8th day: Battle of Weissenburg

Weissenburg is principally of interest, owing to its having been the opening scene of the struggle, and is not of the same tactical value as the other battles which have been mentioned.

Send heavy baggage to Strasburg, or to whatever place may be decided upon, as a point of final departure. Proceed by rail, *via* Hagenau, to Weissenburg; examine battle field with the aid of the map, and thus complete the tour.

Fortification of Metz.

It is impossible to see the Fortifications at Metz without an order from Berlin; this can only be obtained on application by the Horse Guards to the Military Department at Berlin. Permission is not readily granted, owing to the trouble involved; it is an official matter, and would necessitate uniform.

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JOURNAL OF THE MARCH

OF

A HEAVY ELEPHANT BATTERY

FROM

FORTRESS GWALIOR TO CANDAHAR,

BY

LIEUT. L. C. M. BLACKER, R.A.

On the 18th October, 1878, 6/11 Bde., R.A. (now 6/1 Southern Division) marched from the Fortress, Gwalior, with 3 B. L. 40-pr. guns, *en route* for Candahar. The Battery was commanded by Major J. A. Tillard, R.A., assisted by two Subalterns and Surg.-Major Hall.

The guns were let down a steep slope from the top of the Fort in a very simple manner. The road had a slope of from 1 in 8 to 1 in 12, and was about half a mile long, with 4 or 5 very sharp turns. A shoe was made to fit under the end of the trail, the elevating screw was run down as far as possible, and the guns were run down in perfect safety, muzzle first, with the trail scraping on the ground, and about 20 gunners holding on to drag ropes: should more drag have been required, the gun might have been run back into the travelling trunnion holes.

Nothing more of any note occurred until the Battery reached the Chumbul, a very deep, swift and broad river, half way between Gwalior and Agra. Here two guns were safely ferried over, but the third tilted the barge over and fell into the river into about 13 feet of water. Very luckily a native diver with a diving dress and a derrick (and differential blocks) were procured from the railway bridge, which was building near the scene of the disaster, and the gun was extricated in two or three days.

The Battery railed from here to Loodhiana, and marched from there along good roads to Ferozepore Arsenal, where the rest of the equipment, consisting of 3 8-inch mortars, 24 wagons, &c., was issued; they also received 9 elephants and 300 bullocks. The elephants were marched off by road to the Indus at Lukkhur, and the Battery, after ferrying safely across the Sutlej, started for Mooltan, the bullocks giving a lot of trouble by their disinclination to draw through any heavy bits of road.

Halfway from Ferozepore to Mooltan the Battery was ordered to proceed onwards by rail from a road side station named Cheechawutnee.

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The labour of loading up all the wagons and bullocks was very great. Hardly any of the trucks had ends that could be let down, and the side openings were so small that the wagons had to be lifted in bodily. There was also no proper siding with stops from which the loading could be done.

Several of the bullocks split themselves up between the hind legs by slipping up in the trucks during the journey. They also stoutly resisted every endeavour to get them into the trucks, and several had to be dragged in bodily by drag ropes passed round their horns. At Mooltan, Capt. F. L. Graves and Lieut. H. A. Carleton joined the Battery which was now complete, with Lieut. H. E. Hay and myself.

On arriving at Sukkhur (on the Indus) the splendid steam ferry made matters very easy. The elephants swam across in spite of the rapid current.

The march from Sukkhur to Jacobabad was fairly easy.

After leaving Jacobabad the Rutchi desert had to be crossed, and the animals suffered severely from want of water and the heavy sand, which on most occasions stopped the bullocks entirely. The elephants were invaluable, though they occasionally went extremely slowly when it became hot. The cold at night was now very great, going as low as 20° Fahr. during one 32 mile night march. The water was very bad, and had to be cleared with alum. A kind of cattle disease also broke out to aggravate our troubles.

The Battery halted a day at Dadur (the entrance to the Bolan Pass). They entered the Pass on 23rd December, 1878, about two months out from Gwalior, and here their difficulties really began. The Pass is about 90 to 100 miles, and rises about 6000 feet, the steepest part being near the top, where the icy winds seemed to pierce through the thickest clothing.

In the first march the Bolan river had to be crossed about 12 to 15 times, and every team of bullocks (33 teams) jibbed at nearly every stream. By keeping the spare elephants behind and making them shove the wagons through the water, camp was at last reached long after dark, and everybody lay down to rest where he could. The Battery had a Company of the 59th Regiment and a wing of the 3rd Ghoorkhas (who worked splendidly) as escort, and no less than 720 camels carrying food and forage (compressed hay), as nothing of any sort to eat, except mutton, was to be expected on the road. Next day the struggle was resumed, and 10 hours was spent over some very bad ground. On Christmas Day a comparatively (?) easy march saw everybody in camp about 3 p.m. After this the going got worse, and the whole day was spent over marches of 10 or 12 miles, struggling up the dry bed of the river. The elephants were invaluable at the sharp corners where long teams of bullocks could not work; the latter got worse and worse every day. The round pebbles got into the cleft of the hoof and split up the foot of some. These were shot and eaten;[1]

[1] [This reminds one of Marshal Saxe, who insisted that bullock draught was the best for all Field Artillery:—"Si un bœuf s'estropie, *on le tue, on le mange*, et on prend un autre au depôt." "Rêveries &c." Paris, 1757; I., 53. But the good Marshal's "Depôts" did not exist in Afghanistan.—*H. W. L. H.*]

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luckily they had all been shod before starting. They suffered much from galls caused by the yokes getting wet in the river. At last, on reaching the 5th Camp at Sir-i-Bolan, the bullocks were exhausted and lay down for two days, some never to rise again.

As the worst and steepest marches were yet to come, all the shells were taken out of the boxes and sewn up in empty grain bags and slung on the camels, which had become spare through the consumption of their loads. Many of the limber boxes were also loaded thus; and after two days' rest the bullocks marched gaily on with empty wagons behind them. Near the top of the Pass the bodies of an elephant and many bullocks belonging to a preceding Heavy Battery were passed. With the aid of the escort and the 19th Bengal Lancers, the Battery was dragged over the top of the Pass, as many as 6 elephants being hooked into each gun. They did a double march of 22 miles in 20 hours, and then marched on six hours afterwards on 1st January into Quetta (ten miles more).

The ammunition, as was afterwards done in the march up to Cabul, should be carried on camels in proper boxes.

The marches from Quetta to Candahar were comparatively uninteresting. At one place (Shah Passund, a few marches from Candahar, where the news of the Cavalry skirmish of the 15th Hussars and 1st Punjaub Cavalry with the Candahar Cavalry first reached the Battery), one elephant's life was saved in a peculiar manner. She got an ulcerated mouth and could eat nothing hard. Luckily some rice and ghee (clarified butter) had been found on the road, and by making balls of these, and forcing them down her throat, she was fed until she recovered. A bottle of rum mixed up with their cakes formed an excellent stimulant for the elephants. Great care was also taken that they got their food cooked, even after the hardest march, and the Battery only lost one elephant within sight of Candahar. Its life might have been saved had we possessed another bottle of rum. The bullocks were greatly exhausted by not having time to chew the cud. The great and chief difficulty was the absence of forage for the camels; however, by feeding them on grain nearly all their lives were saved, although the cold killed some of them.

The Battery marched into Candahar complete, as regards its ammunition, exactly three months out from Gwalior, and only a few days after Sir Donald Stewart's triumphal entry into the city.

The lesson to be learnt from this march is the inadaptability of bullocks to a stony country like Afghanistan, and the defective system of yokes and drivers, which ought to be assimilated more to the Cape system. The elephants' girths were difficult to keep tight, and galls were therefore soon formed, which took months to heal. The draught in elephant harness is principally from the girth, two or more elephants being hooked in in front of each other, tandem fashion.

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SIMPLE FARRIERY

IN THE ABSENCE OF PROFESSIONAL ASSISTANCE:

WITH A

TABLE OF WEIGHTS AND MEASURES.

BY

CAPTAIN J. HOTHAM, R.A.

THE object of this paper is as follows:—

In many cases, both at home and on service, small detachments, such as Troops of Cavalry, Batteries, or half Batteries of Artillery, may be detached without a Veterinary Surgeon, sometimes even without an experienced Farrier Sergeant. The Officer in charge may not have studied Farriery at all, and his Shoeing-Smiths may be young and inexperienced, and not competent either to detect the symptoms of different diseases, or to treat them on their own responsibility.

Whilst going through a short course of instruction in the Veterinary School in Poonah, under Mr. Lamb, V.S., and Mr. Spooner, V.S., simultaneously with various Farriers and Shoeing-Smiths from many Cavalry Regiments and Batteries, I noticed many who, though excellent smiths and capital nurses, failed altogether in the knowledge of symptoms and treatment of even the most simple forms of disease. I have endeavoured, therefore, from my own notes, and with the aid of books, to lay down clearly the symptoms and treatment of a few of the most simple cases, and thus to assist the Officer in charge and his Farrier, to detect such symptoms, and to treat such cases.

If severer cases of illnesses occur, I can only advise calling in, before too late, a professional man; for only a course of long study and practice will enable a man to detect the different stages of severe illnesses.

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Weights and Measures.

Apothecaries Weight.			Fluid Measure.
20 grains...	make ..	one scruple ℈	60 minims make one fluid drachm.
3 scruples	" ...	one drachm ʒ	8 fluid drachms make one fluid ounce.
8 drachms	" ...	one ounce ℥	20 fluid ounces make one pint.
16 ounces	" ...	one pound lb	

Before detailing the symptoms and laying down the treatment of different simple cases, a few words of caution against the too frequent use of physic may be useful.

Nearly all medicines are more or less poisons, and therefore the less we use them the better. The question is then, "How is it possible to avoid using physic?" The answer to this is, that by securing for horses good grooming, good forage, plenty of ventilation and regular exercise, but very few drugs will be required. The troop horse gets, as a rule, this treatment; and if notice be at once taken of any unusual circumstances connected with him, such as his being dull or off his feed, &c., and if he then be put in a cool box, his hay and corn stopped, bran mashes, and some change of diet substituted for a few days, active treatment will in most cases not be required. There is, however, one great difficulty to contend with: a horse not having the power of speech, cannot tell how or what he feels, and the only guide the Farrier has are the visible symptoms.

Symptoms.

A symptom is defined somewhere as everything, or anything happening in the body of the patient capable of being noticed, which assists in determining the seat or nature of the ailment, and its proper treatment. There are two classes of symptoms—local and general. A symptom is called local when it is confined to the diseased part; and general when the whole system of patient is more or less affected. There are several guides to symptoms of diseases, viz., the visible mucous membranes, the pulse, the condition of coat, the internal temperature of body, and the temperature of extremities and the respiration.

The Visible Mucous Membranes.

The mucous membrane is the thin velvet-like skin which lines all internal parts. The visible mucous membranes are the internal covering of mouth and lips, the nostrils and eyelids. Yellowness of these, especially of the mouth and eyes, indicate symptoms of some *liverish* affection; redness, as a rule, some class of inflammation; spots on the mucous membrane denote a bad state of the blood.

The Pulse.

The pulse in all animals is a leading guide to the state of health. It shows the action of the heart: for the heart, by pumping the blood through the arteries, causes them to beat. The number of beats per minute of the pulse in a healthy horse, in an ordinary temperature, are from 32 to 36. It may however vary from 28 to 40, without anything being amiss.

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To take Pulse.

The most convenient place is the submaxilliary artery, between the jaws. In taking pulse, avoid frightening the patient, for any excitement will cause pulsations to vary. Place the fore and middle fingers across the artery to get the true beat of pulse. There is not space here to go into all irregularities of pulse; but any great irregularity is the strongest symptom of some grave disease.

The Condition of Coat.

A dry and scurfy coat shows that something is amiss. This condition (called hide-bound) is a symptom, among other disorders, of indigestion. A staring coat may indicate worms, or cold; it is, at all events, a symptom that the state of health is not satisfactory.

Internal Temperature.

The ordinary heat of interior of body is from 98° to 100° Fahrenheit. To ascertain internal temperature, insert a self-registering thermometer up rectum. Any rise of temperature above 100 Fahrenheit denotes disease. A change of temperature may be noticed, after short practice, simply by inserting your hand in the animal's mouth.

Temperature of Extremities.

In inflammatory diseases, the legs and ears will be often cold. If deadly cold, fear some danger. If, in addition, a cold sweat breaks out on body, fear the worst. In milder diseases the temperature of extremities will vary much; three legs may be warm and one cold, or one ear warm and the other cold.

Symptoms afforded by Breathing.

Quick breathing is noticeable in many diseases; but as breathing depends on circulation, if circulation is quickened by ordinary causes, so will the breathing.

Difficulty in Breathing.—This is a certain symptom of some disease, probably Inflammation of Lungs, Pleurisy, or some disease of the throat. ***Stentorian Breathing*** (Lungs).—Is usually a symptom of some disease of brain. ***Abdominal Breathing,*** or breathing without using the muscles of chest. This is a certain symptom of some Lung disease. ***A moist cough*** is noticed with Catarrh and Bronchitis. ***A dry cough*** with Pleurisy, and disease of stomach and liver.

Mode of giving a Ball.

Take the horse's tongue in the left hand, drawing it slightly out of off side of mouth; raise the head, and pass the ball with right hand to root of tongue; when the ball is there allow the animal's head to remain on a level with his body, thus enabling him to swallow naturally. Do not let the head completely down, or the skin and muscle of neck will relax, and you will not be able to notice the ball passing down. The passage down will be noticed on the near side. If the ball does not go down readily, give the patient a gulp of water, or a mouthful of grass.

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To give a Drench.

If there be no proper drenching bottle, a soda water bottle is the best substitute. Raise the horse's head slightly and insert the bottle in side of mouth, allowing the liquid to trickle slowly down throat. Some drenches will cause choking and coughing, in that case release the patient's head at once, until the fit of coughing is over. Never on any account administer a drench by the nose.

Poulticing.

Poultices may be made of linseed, bran, bread, or carrots. Linseed is the most drawing and the best for nasty sores. A carrot poultice is a very healing one. In applying a poultice care must be taken that it is hot, big enough, and applied over the proper spot, so as not to slip with the movement of patient, without being tied so tight as to arrest the circulation.

Fomentations.

To obtain any result from fomentations, they must be continued for a very long time, say, two hours at a time. The water should not be too hot, or it will take off the hair. If you can bear the hand in the water comfortably, it will be about right. Allow water to trickle over inflamed parts. In fomenting legs, woollen bandages may be wrapped round and kept wet with warm water: they will retain the heat for some time. Fomentation is the simplest and best remedy in all cases of Inflammation where there is heat, bad sprains, &c. Three fomentations in twenty-four hours are sufficient. Between times, the fomented parts should be covered with flannel to keep out the cold.

Cold Applications.

Cold applications harden and brace up the parts to which they are applied. They also reduce the heat. They are very useful in cases of sprains, bruises, &c., when the inflammation has been reduced by hot fomentations. Cold water bandages are the most common application: the water may be allowed to trickle over the part by means of an india-rubber tube, if you have one.

Purgative.

Purgatives act on the intestines, exciting them to greater action, and thus causing evacuations. The increased action of intestines, draws off secretions, which are got rid of. Purgatives also relieve the intestines from undigested materials; they clear the blood and excite healthy action of liver. Before giving purgative medicine, prepare the horse for physic for 36 hours, by stopping hay and corn, and giving nothing but mashes; never administer a purgative without preparing the patient. The stomach then being empty, the medicine will act on the whole surface. Six or seven evacuations will be enough; give the ball in the morning, and keep horse on mashes with plenty of water that day. Purgatives should never be administered to a horse in a weakly condition. After purgative allow 2 days before putting patient to work.

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Symptoms and Treatment of Simple Cases.

Colic.

Spasms of Muscular coat of any part of Intestines.

Symptoms.

Spasms of pain in abdomen. Kicking at seat of pain. Rolling. Variation of pulse. Pain will cease for a time, and then come on again.

Flatulence. If belly be much swollen. Caused by gas generated from bad food.

Treatment.

Walk and trot about. Rub belly well. Maintain heat of body by means of clothing and bandages. Clyster of warm water and soap.

Drench. 1 drachm powdered opium, 1 ounce nitric ether, 1 ounce aromatic spirits of ammonia.

Prolonged Attack. Repeat drench. Foment belly with hot rugs. Rub in turpentine liniment—spirits of turpentine 1 ounce to 6 ounces of oil.

Inflammation of Intestines.

Symptoms.

Much like colic, but the pain is continuous, not spasmodic. In inflammation there are *no intervals of ease.* Pulse from first to last highly accelerated. Mouth chilly. Ears deathly cold.

Treatment.

Foment belly, rub in turpentine liniment.

Clyster.—Small quantities of warm water.

Drench.—½ to 1½ drachms powdered opium dissolved in water. Repeat in smaller doses. No favourable change from 12 to 24 hours, expect death. If better, careful treatment, change of diet. This is a dangerous disease, and, if possible, a Veterinary Surgeon should be called in. If opium proves of no use, try aconite, from 7 to 10 drops every 2 hours, for 5 or 6 doses.

Super-Purgation.

Symptoms.

Over-purging, due to administration of physic: bad physic and other causes.

Treatment.

½ ounce nitric ether, ½ to 1 drachm powdered opium, and a little chalk. Rice or oatmeal gruel. Dry food.

Fever.

Symptoms.

Horse off his food and dull. Mouth hot. Pulse high. Staring coat. Cold extremities.

Treatment.

Bran mashes. Cool box. Warm clothing. Change of diet. Stop corn and hay. Plenty of water always with animal, with nitre 1 to 2 drachms. Give nitric ether 1 ounce, spirits of camphor from ½ to 1 drachm. Repeat.

Cold (Common Catarrh).

Symptoms.

Off feed. Running at nose. Slight cough. Occasionally swelling under throat. Feverish. Staring coat. Depression.

Treatment.

Cool box. Warm clothing. Bandages. Stop hay and corn. Laxative diet. Mashes, and grass or carrots. Steam head. 1 ounce nitric ether night and morning in water.

Sore Throat.

Symptoms.

Same symptoms as catarrh. Horse off feed. Running at nose. Feverish. Cough. Swelling between jaws. Occasionally, from the throat being sore, horse will quid his hay, slobber at mouth, also cough violently when feeding or drinking.

Treatment.

Good air. Warm clothing. Stop hard food, anything hard will irritate throat. Give plenty of water with a little salt or nitre in it. Steam the patient's head well three times a day. Mashes, green food, linseed and hay tea. Slight febrifuge, 1 ounce nitric ether, 1 ounce aromatic spirits of ammonia; or camphor 1 drachm, nitre 2 drachms. Apply a stimulant to throat—mustard or turpentine liniment.

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Strangles.

OCCURS CHIEFLY WITH YOUNG HORSES WHEN FIRST TAKEN UP.

Symptoms.

Symptom same as sore throat. Horse may be dull and off feed for 2 or 3 days before cold appears. Swelling will shortly appear between jaws. Fever may run rather high. Swelling increases, forms abscess; when burst animal will quickly recover.

Treatment.

Treat the same as for sore throat. If swelling comes on and does not go away in a day or two, but gets larger, an abscess is forming. Warm fomentation to abscess. The abscess will point, and, in favourable cases, burst. If not, it must be opened with lancet; great care must be taken in performing this operation on account of arteries. Opened, keep open to heal from bottom; liberal diet. Tonic—quinine ½ to 1½ drachm doses.

Influenza.

ARISES CHIEFLY FROM BAD VENTILATION OR DRAINAGE, DEBILITY.—IS VERY CATCHING.

Symptoms.

1st stage.—Horse is dull and off his feed. Sweats easily at work. Slight cough. Bowels constipated. Dung slightly yellow.

2nd stage.—Bad coat. Refuses food. Dung very pale, pellets glazed. Mucous membrane, mouth and eyes slightly yellow. Mouth hot. Coughs. Horse staggers in his walk.

Treatment.

Loose box. Warm clothing. Soft food. Plenty of fresh water. Influenza having fairly set in, it must run its course. Careful nursing and feeding. Give 1½ ounce nitric ether every 6 hours. If very weak, give 1 to 2 drachms carbonate ammonia with ginger every 12 hours. If throat appears sore, apply slight counter-irritant—mustard or turpentine liniment.

Bronchitis.

INFLAMMATION OF THE BRONCHIAL TUBES.

Symptoms.

1st stage.—Slight cold and cough. Off feed, Feverish.

2nd stage.—Quick breathing (positive sign). Pulse quickens. Mucous membrane red. A wheezing grating sound heard if ear be applied to chest.

Signs of recovery.—Fever abates. Free discharge from nose. Mucous membrane resumes ordinary colour.

Treatment.

1st. Loose box. Bandages. Warm clothing. Stop corn and hay. Substitute mashes, grass or carrots. ½ oz. nitric ether in water twice a day.

2nd. If disease pronounce itself, give 5 to 10 drops aconite every 4 hours. If no better after 5 or 6 doses, stop. Weakness is noticed, give ½ oz. nitric ether with ½ ounce aromatic spirits of ammonia every 6 hours. Steam head well. Apply turpentine liniment (1 ounce spirits turpentine to 6 ounces oil). Careful treatment for some time after recovery. No fast work.

Pneumonia. Pleurisy. Pleuro-Pneumonia.

INFLAMMATION OF LUNGS, OR OF THE COVERING OF LUNGS, OR OF BOTH.

Symptoms.

Loss of appetite. Quick breathing. A decided symptom is the emission of a sharp grunt of pain when obliged to turn in the stall, or if pressure be applied to side. The horse will look frequently at his sides, his nostrils will be dilated. Pulse quick. Extremities cold. As disease increases, membrane of nostrils becomes deep red colour. If the ear be applied to chest, a grating noise will be heard. Animal will stand with legs apart.

Change for worse.—Ears and legs deadly cold. Membrane assumes purple hue. Pulse weakens, though quick.

Change for better.—Extremities get warmer. Membranes resume natural colour. Pulse and breathing become natural. Horses with these diseases never lie down.

Treatment.

1st. Good nursing and laxative diet. When decided symptoms show themselves, 5 to 10 drops tincture of aconite every 6 hours, if fever is high. Try to warm extremities by flannel bandages. Hand rubbing. Turpentine liniment or mustard application. Blister sides and chest,—biniodide of mercury 1 to 12; or frequently with mustard, washing it off. If strength begins to fail, ½ oz. nitric ether with a little quinine every 4 to 6 hours. Good nursing and sustaining the patient's strength are the main things. Tempt appetite in every way—carrots, linseed, crushed oats, &c. New milk, fresh eggs, and porter are very beneficial when patient is too weak to eat much solid food.

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Diseases of the lungs being of a highly dangerous character, on detecting symptoms, and suspecting this disease always call in, if possible, professional advice.

Glanders and Farcy.

These diseases result from some poison in the blood, with specific inflammation. Farcy may sometimes be cured: glanders never. The poison appears specially in the absorbents or glands. Hence the name of disease. Glanders usually appears in or about head. Farcy as frequently in the hind quarters as the fore.

Farcy.

Symptoms.	*Treatment.*
Fever. Swelling of some absorbent. Glands become corded. Break out in yellow ulcers. Sometimes it shows itself by a painful swelling of hind leg.	Remove animal at once from the neighbourhood of any others. Pay great attention to general health and feeding. Treat ulcers,—biniodide mercury ointment 1 to 8. Administer tonics—quinine.

Glanders.

Symptoms.	*Treatment.*
Fever. Swelling of submaxilliary gland. Nasty discharge from nostrils. Further symptoms,—The swelling will become hard. Discharge very offensive. Nostrils will ulcerate.	On the first sign of these symptoms remove at once the animal from vicinity of other horses. No cure. (Assemble a board at once.)

In cases of farcy or glanders you must get, at any cost, professional advice. With suspected glanders, the only thing is to isolate animal, and watch. Horses have been destroyed for glanders which have never had it. But with this terrible disease, which once it appears is so hard to stamp out, every precaution is necessary on the first symptoms appearing. The utmost care must be taken in treating glandered horses, for the discharge is highly poisonous to men.

Staggers.

AFFECTION OF BRAIN, ARISING SOMETIMES FROM INDIGESTION, AT OTHERS, FROM ABSCESS ON THE BRAIN, OR SOMETHING AFFECTING THE BRAIN. WHEN ARISING FROM INDIGESTION IT IS CALLED STOMACH STAGGERS.

Stomach Staggers.

Symptoms.	*Treatment.*
Stomach distended. Pulse low. Patient drowsy. Staggers when he walks. Eyes bloodshot and half closed.	Give at once a large dose of opening medicine. Clysters, &c., to clear out the stomach. Apply turpentine liniment to legs.
Mad Staggers. Signs of madness appear.	In case of mad staggers, keep animal quiet in the dark. Apply cold water to head. Prevent animal from injuring himself in the mad fits. Bleeding is the best remedy for the latter case.

Bloody Urine.

ARISES FROM INFLAMMATION OF LINING OF KIDNEYS, THE BLADDER, OR URETHRA.

Symptoms.	*Treatment.*
Dark coloured urine, mixed with blood.	Laxatives, grass, linseed tea. Stop corn. Rest.

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Excessive Staling.

ARISES FROM BAD FORAGE, OR BAD WATER, AS A RULE.

Symptoms.
Excessive staling. Skin dry. Rough coat. Drinks freely. Feeds badly.

Treatment.
Laxative diet. Grass. Linseed tea. ½ drachm iodine for 3 or 4 days. Nitrated water (2 drachms in pail of water).

Retention of Urine.

ARISES FROM INFLAMMATION OF NECK OF BLADDER, OR CALCULI; SOMETIMES FROM DIRT ACCUMULATED IN URETHRA OR SHEATH.

Symptoms.
Straining to pass urine. Pain. Feverish symptoms. Pulse high.

Treatment.
Wash out urethra with warm water. Administer clysters,—warm water. Pass hand up anus, and press gently on bladder. Hand rub belly. Give aperient ball. Careful diet. Linseed tea. Barley water.

Inflammation of Kidneys.

ARISES CHIEFLY FROM EXPOSURE, A SUDDEN CHILL, OR SEVERE WORK.

Symptoms.
Fever. Pain. Horse stands legs apart. Tenderness over loins. Tries to stale. Passes small quantities, tinged with blood. Pulse quick.

Treatment.
Foment loins. Give a pint of oil with one scruple calomel. If effective, when purging ceases, ½ drachm calomel, ½ drachm opium for 2 or 3 days. If effective, and urine passes and gives much pain, ½ ounce bicarb. of soda twice a day. Hay. Linseed and barley tea, all good. Food laxative.

Derangement of Liver.

Symptoms.
Bad appetite. Harsh skin. Mucous membrane of a yellow hue.

Treatment.
½ drachm calomel for 3 or 4 days. Taking care to stop calomel at once when bowels act.

In all cases where calomel is used great care must be taken, for over doses are very dangerous.

Congestion of Liver.

Symptoms.
Bad appetite. Bowels disordered. Mucous membrane of a decided yellow tinge. Dung light coloured and stinking. Hollow cough.

Treatment.
Calomel, scruple doses, 3 per day until bowels act, then stop at once. Diet sparing and laxative. Hot fomentations and mustard. If weakness shows itself, ½ ounce nitric ether with a little quinine every 4 to 6 hours. If secretion of saliva from mouth, stop calomel at once.

If inflammation of liver sets in, bleeding is necessary; stop calomel. Blisters over seat of liver—biniodide mercury, 1 to 12.

Tetanus.

A PERSISTENT CONTRACTION OF SOME VOLUNTARY MUSCLE RESULTING FROM DISEASE OF NERVES.

Symptoms.
Closing of jaw. Animal cannot swallow. Haw protrudes over eye. Limbs become rigid. Tail upraised. Muscles stand out.

Treatment.
Perfect quiet. Dark box. Warmth. Nitrated water. No cure as yet discovered.

Wounds.

Simple Wounds.—Wash carefully by allowing warm water to trickle over; remove all dirt and bits of skin. Apply cold water and lint.

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Deep wounds must be kept open so as to heal from the bottom and not from top; for in the latter case, the matter forming could not escape, and would burrow underneath.

Indolent wounds may be stimulated by a little application of carbolic acid diluted with oil, 1 to 32. Wounds will often granulate too freely, and form *proud flesh*; rub this over with the blue stone, or apply a little calomel. In cases of deep cuts where there is not much flesh, such as about legs or head, the sides may be drawn together by wire sutures, put in with a curved needle.

Lacerated wounds will often require poulticing to reduce the inflammation. After this, if healthy, apply cold water and lint. If unhealthy, first apply blue stone. Wounds in hot climates soon get maggots in them; to kill these, inject turpentine and oil in equal parts.

Saddlery Galls.

Comprising sore backs, girth galls, &c. If skin be not abraised, apply salt and water, and relieve pressure on part by removing stuffing of saddle, or using pads, &c. If a raw be formed, apply tincture of myrrh and aloes: or carbolic oil, 1 to 32 (keeps off flies), or Friars' balsam.

Bruises and Contusions.

In cases of bruises or contusions where there is swelling, foment well and then dress with cooling lotion,—Goulard's extract, 1 to 6 of water, or vinegar 2 ounces to a quart of water. In cases of small bruises and chafes from saddles or harness, where the skin is not broken, salt and water will prove very beneficial.

Broken Knees.

If only bruised and the skin be not broken, apply cold water and cooling lotion. If the skin be cut, cleanse the wound with warm water, and apply cold water and lint, placing a bandage over to keep the dressing in its place: great care must be taken that the bandage is not tight. Turn the patient about in the stall and fasten him to the pillar reins for two or three days, to prevent his lying down or knocking the knee against the manger: keep the lint well wet by squeezing a little water on with a sponge.

In the case of a punctured wound, wash out carefully with warm water to get rid of all grit and dirt. Then take a pledget of cotton wool, covered with collodion or white of fresh egg; place this in the wound, thus excluding air and dirt, over this a pad of wet lint; then a light bandage over the whole. If no inflammation sets up, this may be left on for two or three days, re-adjusting the bandage at times. Then remove with warm water, wash carefully the edges of wound, and renew the cotton wool and collodion quickly as before. In a few days the wound should be healed up. Care should be taken to keep lint damp night and day, and that the covering bandage be not too tight. If, however, inflammation sets up and sloughing sets in, this treatment

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will not avail. The pus must be allowed free exit, and endeavours made to stop the inflammation by fomentations. When the inflammation has subsided, then healing process may be set up by using cold applications and mild astringents. If the joint be laid open, or even the tendon cut, this treatment may probably not avail. In all cases keep the injured limb as absent from all motion as possible.

Inflammation of Eyes.

MAY RESULT FROM A BLOW, OR FROM A HAY SEED, OR FROM SOME FOREIGN SUBSTANCE GETTING INTO THE EYE.

Symptoms.	*Treatment.*
Eye closed and watering. Symptoms of pain.	Examine eye carefully, extract anything found there. Warm fomentations. Cooling lotion,—Goulard's extract 1 to 6, with ½ drachm opium mixed.

Skin Disease.

Ringworm.

PARASITIC GROWTH OF FUNGUS, RESULTING FROM DIRT, CARELESS GROOMING, BAD FEEDING, &C.

Symptoms.	*Treatment.*
Bad coat. Scurfy. Blotches of thick scurf forming generally in rings.	Wash with soap and water. Dress with caustic or calomel, or biniodide mercury, 1 to 12. Change diet. Give a purgative.

This disease is very catching; therefore the animal should be put alone, and his brushes be kept for his exclusive use.

Mange.

ARISES FROM NEGLECT, BAD FEEDING AND MANAGEMENT; SOMETIMES FOUND IN REMOUNTS WHEN THEY FIRST COME UP.

Symptoms.	*Treatment.*
Itchiness at roots of hair, shows itself at first, as a rule, about mane and tail. It is caused by insects; the hair comes off, and small pustules form. There is a dusty appearance about roots of hair.	Wash with carbolic acid, ½ ounce to pint of water. After 48 hours wash off this dressing with soap and water. Give laxative medicine. Slight purgative (Epsom salts, 2 ounces) now and again.

Surfeit.

Slight unhealthy appearance of skin, spots, itchiness. Dress part with lemon juice and linseed oil in equal parts, with a little opium mixed. Change of diet. Nitrated water.

Worms.

Bots.—Grubs of the gad fly. All horses have these animals more or less in the stomach. When noticed in dung they are being expelled by nature. A dose of physic may get rid of some, but on account of their thick skin, nothing will act on them to kill them in the stomach.

Intestinal Worms, both long and short.

Symptoms.	*Treatment.*
Bad coat. Dry white matter adhering round anus. They are usually seen in dung.	2 ounces of turpentine in a pint of oil, or 1 drachm of sulphate of iron night and morning for 10 days, or 4 drachms of betel nut on empty stomach.

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Diseases and Ailments of Feet.

Cracked Heels.

GENERALLY CAUSED BY NEGLECTING TO DRY FEET AFTER WASHING THEM.

Symptoms.
Inflammation of skin. Skin gets hard. Cracks and forms a sore.

Treatment.
Dress with a little carbolic oil, 1 to 20. If bad, poultice, bread or carrots, then dress with carbolic oil, or blue stone, if necessary. Or one part of nitrate of silver to eight of water.

Thrush.

DISEASE OF FROG—ARISES FROM STANDING IN WET AND DIRTY STABLES.

Symptoms.
A strong smelling discharge from the frog. Frogs soft and nasty.

Treatment.
Keep the feet as clean as possible. Put pledgets of tow in cleft of frog with hot carbolic oil (equal parts), remove these daily; or if this is of no avail, try blue stone and Stockholm tar, 1 to 8. Bring pressure on to the frogs as much as possible.

Sandcrack.

Symptoms.
A fissure in the horn, commencing at the coronary band, generally in the inner quarter of the fore and toe of the hind foot.

Treatment.
If crack does not extend through the horn, remove pressure from the part by shoeing, and stimulate the growth of fresh horn by a slight blister round coronet. Biniodide mercury, 1 to 12. Keep wet swab on foot. If crack extends completely through, pare out, to facilitate cleanliness. Draw hot iron across bottom of crack, to prevent its extending—¾ shoe. If very bad and much heat and pain, pare away more horn, and poultice. Blister coronet.

Seedy Toe.

A bad secretion of horn, which causes the separation of the outer crust and laminæ. A cheesy material is formed and dirt gets in. Pare away the bad horn and stimulate coronet,—biniodide mercury, 1 to 12. Slight cases—fill up cavity with gutta percha.

Pricks.

FROM CARELESSNESS IN SHOEING.

Symptoms.
The horse after shoeing appears lame. Heat in foot from nail having entered sensitive structure. Pus forms.

Treatment.
If prick be suspected, remove shoe, taking out each nail separately. Seat of prick being found, pare out with drawing knife. Allow pus to escape. Poultice.

A horse may be pricked or wounded by picking up a loose nail, or treading on something sharp.—Treatment just the same.

Quittor.

A FISTULOUS WOUND IN HEEL, OR ON QUARTER OF CORONET, CAUSED GENERALLY BY A SUPPURATING CORN OR AN UNTREATED PRICK. MAY ALSO BE CAUSED BY AN INJURY TO THE CORONET.

Symptoms.
Fistulous sore, very often forms into a sinus. (A sinus is a hollow passage communicating with some abscess or suppurating sore. The walls are lined with mucous membrane. A sinus is very hard to heal up. The walls must be broke through).

Treatment.
If from a corn, pare away the seat of corn, and allow the pus to escape through sole. Poultice and dress the wound with carbolic oil, 1 to 32. If sinus be formed, it is often very troublesome. The walls of the sinus must be broken down, either by cutting with a knife, or caustic. The sore itself must heal from bottom.

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Treads.

From over-reach, tramps from other horses, &c. Cut off loose skin and dress round with carbolic oil, 1 to 32, or tincture of myrrh.

Sprains.

The ligament and tendons are all very liable to sprain, especially with young horses.

Symptoms.	*Treatment.*
Lameness. Swelling. Pain in seat of sprain, also heat.	Hot fomentations until the heat and pain have subsided. Then cold bandages and astringent to strengthen the seat of sprain. Arnica, 1 to 6, rubbed well in may be useful.

Troop horses are more likely to be lame from sprains than from any other source. Slight sprains are soon got over by the above treatment; but severe sprains of tendons and ligaments generally leave some thickening behind them. Rest is the best cure for all sprains. The after effect or thickening of tendons or sheaths of tendons may be absorbed in time by the use of mild blisters of biniodide of mercury, iodine, &c. With regard to lameness arising from splint, spavin, ring-bones, &c., it would take too much room to deal with them in these few pages, neither is it my object to do so. The best cure for lameness, as with sprains, is complete rest; all other treatments are only aids to this, the sovereign remedy. However, wherever the lameness may be, and from whatever cause, if heat and pain be detected, hot fomentations will always relieve the latter to a great extent.

Aging Horses.

The age of horses is told by their teeth. Up to 7 and 8 years, by a slight knowledge of growth of the different teeth, it is an easy thing to tell the age; after that it becomes harder, and is in fact almost guess work.

Teeth.

A horse has in a full mouth of teeth :—

12 nippers or front teeth	...	6 above 6 below.
24 molars or back teeth ...	...	12 " 12 "
Males have 4 tushes	... ...	2 " 2 "

There are cases of females with tushes—but these are few.

Development.

We will now only trouble ourselves about the incisors or nippers, as horses are commonly aged by them. At birth, a foal has 2 central incisors (temporary), milch teeth. Milch teeth are whiter, more constricted at neck, smaller and shorter than permanent teeth. At from 4 to 6 weeks, the lateral incisors appear (temporary). At from 6 to 9 months, the corner incisors appear (temporary). A yearling has a full mouth of temporary incisors. From 2 to 2½ years central tem-

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porary incisors are replaced by permanent teeth. From 3 to 3½ years lateral temporary incisors are replaced by permanent teeth. From 4 to 4½ years the corner temporary incisors are replaced by permanent teeth. From 4½ to 5 years the tush appears in males. Thus at 5 years we have a full mouth, though the corner incisors will only be shells. At 6 years they will be complete. At 7 years the black marks will have worn out of centre teeth and partly out of lateral. At 8 years the marks will only be seen in corner teeth. At 9 years the marks will have disappeared altogether.

The Line of March.

It is on the line of march especially that Officer and Farrier may be called on frequently to treat simple cases, such as galls, harness chafes, kicks, over fatigue, &c. The Farrier should go round and examine every horse in his Troop or Battery, accompanied by his Shoeing-smith, and the Collar-maker and Saddler, after every day's march. Every N.-C. Officer should be most particular in reporting to him on his rounds the slightest case of sickness, horse dull, not feeding, chafing, brushing, &c. In the case of chafes, galls, &c., he will dress at once with liniment, which he should have with him, say: tincture aloes and myrrh, a little Goulard's extract, 1 to 6, and carbolic oil according to circumstances. The Collar-maker will note the saddle or strap which caused the chafe, so as to alter the bearing before the next day's march. In the event of a horse being dull and off his feed, the Farrier might, if he thinks it due to exhaustion, administer a slight "pick-me-up," say, 1½ drs. carbonate of ammonia with 3 drachms ginger, made into a ball: the corn should be removed, and in an hour or so a warm mash might be substituted. In case of extreme exhaustion, administer 1 ounce nitric ether, ½ ounce aromatic spirits of ammonia. If nothing else be handy, a couple of wineglasses full of gin or whiskey in a little gruel will often work wonders. If the patient be still dull the next day, the Farrier should recommend him to be led, and if weather be hot, start him off in the cool of the morning, so as to avoid the mid-day sun.

The shoeing-smiths should examine every shoe, and look for treads, brushing, &c., altering the shoe at once if anything be wrong; if necessary, providing a brushing boot for the next day for any horse requiring it. The dealers' boot, though not so neat as the leather one, is much more serviceable. It consists of a piece of blanketing, tied with a tape round its centre, just about the fetlock joint, the top part being folded down over the tape; it is softer than the leather boot, never chafes, and always covers the wound. In the case of kicks or contusions: a few good warm fomentations often works wonders in taking away the stiffness.

I may mention in conclusion a few of the chief causes of casualties on the march:—

1. When the day arrives to start, the horses are too often soft and

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not in hard condition, therefore they naturally knock up, go lame, and many fall away, and their harness no longer fits them, their necks get wrung with the collar, &c.

2. Some Commanding Officers are persuaded by their Collar-makers and Saddlers to permit, what the latter call stuffing and pricking up the saddles, a day or two before the march. The saddle, if kept in order, and inspected weekly by the Officer, should be always ready. The final stuffing and pricking up just before marching causes, certainly, many chafes and saddle-galls during the first few days on the road.

3. Valises being badly fitted and packed; the valise laying flat on the horses back, and not being well arched over it.

4. Saddles being thrown off the horses backs when hot, and the backs exposed to the air and sun. This should never be allowed.

5. A want of care on the part of the N.-C. O's. and men in looking round their horses, and reporting small casualties at once. At every halt, every saddle and collar, in fact, every strap should be examined, and the slightest thing wrong at once reported. A slight alteration of the bearing of a collar or strap might stop what, in another hour or so, would prove a serious chafe.

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NORMAN RAMSAY'S EXPLOIT.

BY

THE SECRETARY.

THERE are two matters connected with Norman Ramsay's exploit at Fuentes Onoro (Napier's "History of the Peninsular War," Vol. III., p. 150) that seem to me to be well worthy of consideration, although they have hitherto been almost universally overlooked.

The first is, that it is the sole and solitary occasion on which Sir William Napier has bestowed a paragraph upon the Artillery. He mentions, indeed, in his account of various battles, that there were so many guns here and so many Batteries there; but of their services we have scarcely a word. He occasionally alludes by name to Ross' Troop, the Chesnut, which was generally attached to his own, the Light Division; but with Ross he begins, and with Ross he ends. In his well-known comparison between the English and French armies, the Artillery are conspicuous by their absence. It is true the Cavalry have fared nearly as badly. The Cavalry are dismissed with three lines (II., 401): not one word is wasted upon the Artillery. We were not treated thus by even our greatest enemies. General Foy's "History of the Peninsular War" was written in the year 1817, long before the bitter feelings engendered by the war could have been even partially allayed; yet in *his* comparison of the English and French armies he speaks of us in the following words:—*les canonniers Anglais se distinguent entre les autres soldats par le bon esprit qui les anime. En bataille leur activité est judicieux, leur coup-d'œil parfait, et leur bravoure stoïque.* After such a recognition of our services by our enemies, we can afford to be ignored by our friends.

The second point is, that Ramsay's exploit is not, as is generally supposed, unique in the history of war. The Russian Horse Artillery performed an exactly similar feat at Vauchamps, 1814; and a Battery of Prussian Horse Artillery extricated itself from the French Cavalry after the battle of Ligny in a somewhat similar way. Why are these feats forgotten? Because there was no Napier to record them. For we must not permit regimental prejudice to blind us to Napier's transcendent merits. Napier's language is as splendid as Ramsay's dash. His French translators admit Napier's Storming of Badajos and Charge of the Fuzileers at Albuera to be unrivalled in all military history. Even Mr. Buckle, who hated soldiers and all their works; who proclaimed to the world in his "History of Civilization" that we are "deficient in intellect," and that if a man has a stupid son, "he is made either a soldier or a clergyman; he is sent into the army, or hidden in the church":—Mr. Buckle admits that Napier is

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worth reading *for the sake of his style.* Yet not very long since a comparison was somewhere made between the German Official History of the War of 1870, and Napier; and the bald German book was pronounced to be superior to the 'high falutin' of Napier! As well place the lawyer's brief against Warren Hastings before the speech Burke delivered from that brief; as well prefer a reporter's account of the trial of the Seven Bishops to Macaulay's description of that scene; as well say the picture of a milkmaid by a painter of the Flemish School is superior to the picture of the same milkmaid by a Titian, or a Correggio. The Dutchman would paint her perspiring, with a dirty apron, and muddy shoes. The Italian would paint her quite as true to life, without unnecessary sordid details; and yet surround her with such a glow of genius, that we should return again and again to gaze upon her beauty. If a history of certain events is to be written, why should not these events be described in the best and most artistic language? Is a grovelling style more truthful or trustworthy than an elevated style? Would Carlyle's "French Revolution" gain anything by being re-written by a lawyer's drudge? There may be minds, no doubt, to which the monotonous drone of the lawyer's prose is more congenial than the satire of Swift, the irony of Gibbon, or the passion of Burke. But to such persons it is useless to appeal. There are certain fish which love the mud better than the clear water of the stream. The German book, as I have said, is a bald book, describing truthfully the circumstances of the war in a rigid, frigid, repulsive style: Napier describes *his* war quite as truthfully, but in the burning words of genius. The natural consequence is that the German book is only read by those who have an examination to pass, while Napier is read by hundreds who never drew a sword or shouldered a musket. One thing is quite certain:—if Military History is a desirable subject of study for Officers, it should be made as attractive as possible.

Napoleon, having defeated the Allies under Blucher, at Vauchamps, 1814, sent forward a large force of Cavalry and Horse Artillery, under Grouchy, with orders to skirt round the enemy's flank and take up a position upon his line of retreat. This was accomplished in due time by the Cavalry, but the Horse Artillery stuck fast in the mud before they reached their destination. Vauchamps lies in a low, marshy country, and the ground at that particular time was extremely heavy from prolonged falls of rain. While matters were in this state, Blucher at the head of the Allies confronted the French Cavalry. The French Cavalry, so strongly posted upon his only line of retreat that it was vain to think of turning their flank, were before him: behind him, at the head of a victorious army, was Napoleon, whose battle was "the swell and dash of a mighty wave before which the barrier yielded, and the roaring flood poured onwards, covering all" (Napier, VI., 196). Blucher, in great straits, took the only course open to him: he threw himself upon Grouchy; and in the struggle that ensued the Russian Horse Artillery were cut off. Upon this Colonel Shusherin, who commanded, ordered 'Detachments Front,' and advancing at a gallop burst by sheer weight through the lines of the French Cavalry.

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During the Prussian retreat from Ligny, a Battery of Prussian Horse Artillery "became all at once surrounded by French Dragoons. These vainly endeavoured to cut the traces, but the Prussian Artillerymen defended themselves so well that they succeeded in effecting the escape of the Battery through an opening in the enclosures of Bry."—(Sibourne, "Hist. of the Waterloo Campaign," I., 230). Had the exploit of old E Troop been recorded by Sibourne, instead of Napier, would not Norman Ramsay have long since joined Colonel Shusherin and the nameless Prussian Commander, in the Land of Forgetfulness? Most undoubtedly, did his reputation rest upon this one act of headlong bravery. But Ramsay's reputation rests upon a far more solid and enduring foundation:—upon a career marked by unbaffled skill and unwavering courage, from the day he first set foot in the Peninsula until the day he met his death among his guns at Waterloo.

WOOLWICH,
October, 1882.

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PRACTICAL ASTRONOMY FOR EXPLORERS.

BY

LIEUT.-COLONEL J. R. OLIVER, R.A.

With reference to Major Gordon's criticisms of my paper on this subject, I would advise anyone who is likely to have to use portable astronomical instruments, to try them and judge for himself which kind is easiest to manage, and gives the most correct results. From an experience of several years in working with and teaching the use of various instruments, I have no hesitation in preferring the transit theodolite to the sextant. The former is certainly much more costly and heavy, and its adjustments are rather complicated; but one can do much more with it than with the sextant, and the adjustments are easily mastered. Were I proceeding on an exploring expedition I should like to take both instruments: or rather, in addition to the transit, I should like to have either a repeating reflecting circle with three mirrors or a prismatic reflecting circle. They are both free from certain instrumental errors to which the sextant is liable, and have the advantage over it that they will measure angles of any magnitude. I may remark here that there is little use in having the sextant graduated to read to 10 seconds, when (as is often the case) the optical power of the telescope is so small that one cannot be certain of the contact of the images to within half a minute.

The plate of glass lying on the surface of the mercury is, no doubt, a great improvement; but, in spite of what Major Gordon says, I must repeat that a too small horizon *is* very troublesome to work with.

I am glad to hear that chronometer making has been brought to such a pitch of perfection in England; but I cannot admit the statement that "chronometers showing Greenwich Mean Time do not exist." It would have been superfluous for me to mention the well-known correction for rate.

Kingston, Canada,
23 October, 1882.

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MEMORANDUMS

OF

ARTILLERY ARRANGEMENTS AND ALTERATIONS

MADE IN

CARRIAGES, HARNESS, AMMUNITION, &c.,

ON THE

EXPEDITION TO EGYPT, 1801,

BY

BRIGADIER-GENERAL LAWSON,

COMMANDING THE ROYAL ARTILLERY.

NOTE.

EXTRACTS from the following Paper appeared in the "Short Notes," which were issued with No. 11, Vol. V., of the Proceedings.

The whole Paper is now given in consequence not only of its intrinsic merits, which are great, but of the peculiar interest attached at the present moment to everything connected with Egypt.

Brig.-General Lawson, the author of the "Memorandums," became a Fireworker in 1759, and a 2nd Lieutenant in 1766. At the close of the Egyptian Campaign he was mentioned by Sir John Hutchinson, the General Officer Commanding (on the death of Sir Ralph Abercrombie), in the following words:—

"Brig.-Gen. Lawson, who Commanded the Artillery, and Captain Brice, the Chief Engineer, have both great merit in their different departments. The local situation of Egypt presents obstacles of a most serious kind to military operations on an extended scale. The skill and perseverance of these two Officers, however, overcame difficulties which at first appeared insurmountable."

He died in Woolwich in 1816, a Lieut.-General and Colonel Commandant of the 10th Battalion.

THE Expedition under the orders of Admiral Lord Keith and General Sir Ralph Abercromby proceeded from the Island of Malta on the 21st of December, 1800: arrived at Marmorice Bay, in Asia Minor, on the New Year's Day following, and remained there waiting the co-operation of the Turks (being the time of their Ramasan) until the 20th of February. During this period every measure was taken the situation

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admitted of to lessen the numerous difficulties expected to be met with in Egypt, such as a dangerous shore to land upon, a country destitute of wood, water, or roads; where, as the Commander-in-Chief informed the General Officers (assembled by order), nothing was to be looked for but a wild waste of desert and obstacles, which the most unremitting exertions had only a chance of surmounting, independent of a formidable opposition from the French Troops.

Under these ideas, and the Battering Train (originally designed against Bellisle only) having joined the Army—very indifferently provided, indeed, for such an uncommon arduous enterprize—no time could be lost. All the artificers were landed, and strong working parties sent into the woods to cut down timber for making additional spars, skids, and various-sized rollers, to form gangways for landing the heavy ordnance upon, assisting them over deep sandy beaches, and in crossing the canals—formed for conveying the rising waters of the Nile into the towns and cultivated spots of the country.

The general acknowledged difficulty of travelling wheeled carriages in Egypt induced the trial of a number of contrivances to lessen that inconvenience also: the first of which, and most obvious, were a kind of litters, as represented by the drawings in the 1st Plate, termed—

Horse Barrows.

No wood growing in this country proper for such purposes rendered it necessary to dig saw-pits, in order to cut the pine timber into long scantling,[1] something near the shape of a common handbarrow; preserving the grain as entire as possible. Two movable cross-bars, which are secured by two small bolts, keep these shafts at a proper interval to admit a horse at each end between them. The drawings show the figure and manner of travelling the machine by two horses or mules, each having a small cart-saddle with girth, backband, breastplate, and crupper, and a halter for leading them by. These barrows were particularly useful for narrow paths and the trenches of an attack, or for conveying any individual weight too heavy for a single horse—such as a small piece of ordnance, standing carriage, large casks of provisions, &c.[2]

Besides these single barrows, a design was formed for double ones, consisting of three shafts, as seen in the drawing, Fig. 2, to be carried by four horses in pairs; and also others upon a still larger scale for camels; but neither time or materials admitted of their being put into immediate execution.

A very considerable number of carrying-poles, about nine feet long each, were formed out of the small-sized trees, to which rope slings were added, for the soldiers to convey kegs of musket ball-cartridges, ammunition boxes, or royal mortars with, as represented by Fig. 3.

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[1] Sixteen feet in length and about four inches square.

[2] The powder and ammunition expended in the Attack of Aboukir Castle was mostly conveyed from the landing-place to the Batteries in this manner.

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Horse Harness and Drill Park.

A number of horses were purchased at Constantinople on the part of the English Government, and sent to Marmorice, for remounting the Light Dragoons, and those rejected by them were handed over to the Artillery Service. Such poor undersized animals, as they were, rendered it absolutely necessary, not only to take the harness entirely to pieces in order to bring it anything near fitting them, but also to lay aside all the heavy parts, such as neck collars, chain traces, curb bits, &c.; and replace them with light leather breast collars, rope traces, and pads formed out of the wagon harness—a great part of which, fortunately, was not likely to be otherwise called for. About 130 horses being thus completed with harness, some light pieces (guns and howitzers) were landed and a small park formed, in order to drill them to the draught. Every reform possible was made to lighten the travelling of the ordnance; and it was very much wished to have exchanged the limber shafts for poles also, on account of their weight, as well as other considerations; but no proper wood could then be procured, even at the Island of Rhodes, for the purpose. The block-trailed light 6-pr. carriages had ten horses allotted to each for draught, but the framed ones required twelve when going over heavy sand or shingle.

A few of the most useful Horse Artillery manœuvres were also practised here, it being the Commander-in-Chief's intention to establish some pieces on that principle whenever horses could be procured for it. Drivers were also very much wanted; several of those which came out originally with the Battering Train having, with their Officer, returned in a very unaccountable manner from Lisbon[1] to England.

Considerations submitted to the Commander-in-Chief at Marmorice Bay, 10th January, 1801.

1st. As the passage of the Fleet to the coast of Egypt may probably be short, it is humbly proposed to have the light field-pieces of the First Division of Troops conveyed from hence on the decks of the Ships of War, so as to be at once lowered down altogether into the boats, having their Artillery detachments along with them, without the necessity of any other preparation after coming to anchor.

2nd. The Ordnance Ships, in which the other pieces next for landing are aboard, to be conducted and stationed by the Agent himself (the Masters alone not being sufficient at such a crisis) as near to the shore as safety will admit. And it will be necessary, on account of the crowded manner in which they were loaded in England (being taken upon freight), to have light vessels along side of them, to receive the water casks and articles, not immediately wanted, in clearing away to those sought for.

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[1] After the attempt on Cadiz, part of the Battering Train went to Lisbon, but remained there only a short time.

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3rd. Small vessels, or decked boats, with field ammunition and musket ball-cartridges will be required (particularly if the coast proves shallow) still nearer in-shore, and to be stationed opposite the centre of attack, immediately after the landing of the First Division of the Troops, distinguished by ordnance jacks. In order to furnish the most speedy supply possible, a number of hand-carts and carrying-poles may be thrown on shore from these boats for the soldiers to take off any ammunition wanting until the horses can be landed.

4th. The flat-boats and launches of the Ships of War are wished to be employed in conveying the field ordnance, &c., ashore, instead of transport's long-boats, which (as was experienced at Cadiz), from their want of hands and general size, are quite inadequate to the business.

5th. Planks joined together lengthways by staples and cordage may be necessary to travel the carriages upon over heavy sands. The French, it is said, made use of raw hides in passing the Deserts with their field-pieces. Perhaps lengths of rope, about 30 feet each, with narrow netting between to receive the wheels upon, might be found as useful, and in our situation more readily procured.

6th. One thousand seamen, provided with drag-ropes or harness, will be required to assist in landing and drawing up the heavy ordnance and stores.

7th. The mode of advancing into the country will depend upon the means of draught found there; but, at all events, if a strong detachment of seamen can be procured to remain with the Artillery, it will be highly beneficial to the Service.

Agreeable to these representations, application was immediately made to Lord Keith, who consented to take aboard each of the Line-of-Battle Ships two field-pieces, which were placed on the poops, ready for lowering down into the launches altogether. Twenty-five seamen and Officers were allotted to each piece, with fifteen of the Artillery. These 350 were all the seamen his Lordship could spare out of the 1000 demanded.

Two general rehearsals of landing were then practised—the guns got ashore very readily, and quicker than the troops could leap out of their boats. Each Ship of War formed its own boat's gangway—the best of them was made out of the fishing of a mast, which, being hollow, secured the wheels of the carriage from slipping without side-pieces.

Alterations made in Carronade Carriages.

The moving of heavy ordnance over the Deserts of Egypt the French thought impracticable, and attempted no larger calibre than 8-prs. or 12-prs. Something more, however, seemed necessary for us to make trial of against an enemy so much more formidable than they had had to contend with, independent of the ambition of superior resource.

Upon comparing all circumstances together it appeared likely that, whatever works they might have raised in the interior of the country since their possession of it, could not be very solid ones, even if composed of masonry—for want of time to settle and the cement to harden sufficiently in such substances. And earth alone, in this climate, must

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soon crumble to dust or sand, and easily be destroyed by shells. From these considerations, it was concluded, carronades might probably be found sufficiently powerful to breach them in either case at moderate distances, and be easily conveyed by the double horse or camel barrow across the country, if necessary. The circumstance being suggested to General Sir Ralph Abercromby, and, at the same time, the means proposed of altering the carriages for this purpose, without affecting their sea service in the smallest degree, His Excellency communicated the idea to Lord Keith, who immediately ordered several of these 24-pr. carriages (the larger ones were wished for) ashore from the Ships of War to undergo the necessary alteration. This operation being soon executed, some trials of shot and shells were made there, and afterwards aboard the "Foudroyant," in presence of the Admiral and General—much approved of. The drawings, Plate 2, show the design;[1] the additional parts added to make the carriage more serviceable could be separated from the carriage in a few minutes, leaving it in its former state for sea service. These carriages have one considerable advantage, which, indeed, all those intended for Sieges or Barbette Batteries ought to possess, that is (the upper part turning upon a centre independent of the base), they require little or no platform,[2] by which much expense, time, and labour may constantly be saved, not to mention the hazard of losing the artificers usually employed on these occasions.

Arrangements of Field Ammunition.

Many mistakes, as well as loss of time, happening on service by the ammunition being sent into the field with the wagons accompanying the guns in the same state as lodged in the store-houses, that is, round shot, case shot, cartridges, and small stores (each article in separate packing boxes), it was thought advisable, especially on this occasion, where the ammunition must be mostly carried on camels' backs, to complete each individual box with a certain number of rounds (one-fourth case), including small stores, and everything necessary to the firing of them. This was effected by only raising the round shot packing-box about two inches higher, and the addition of a small board as a false bottom, which admitted of stowings, as follows: viz., for light 6-prs., fifteen rounds[3] and one extra case shot; light 12-prs.,

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[1] It may be observed the carriage slide is here reversed, that is, the sea-front becomes the land-rear, which is supported by a block of wood (*a*), secured by the two bolts (*b b*); the iron rollers are removed from their original situation (*c c*) to the new iron bracket (*d d*); but this was soon improved upon, and rendered general for either Service by forming the iron frame for the rollers, as represented by Figure 2, with a strong square shank (*e*) to slip into the iron loops (*f f*), so as to give the rollers either of the two directions required (traversing or recoiling), without the necessity of removing them from one place to another at any time. The upper carriage is prevented from recoiling on the slide part by the cross bolt (*g*), without hindering its traversing to right or left.

[2] From this consideration, and the lightness of carronades, the Navy Officers present at the experiments were of opinion this alteration would be very useful to their Service also, for taking up small posts occasionally ashore.

[3] Part of the groove ends of the wood bottom, to which the cartridge was formerly tied, were cut off to stow the closer.

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eight rounds; medium 12-prs., seven rounds. For the royal howitzers' ammunition it was necessary to have two packing-boxes on this principle, viz., one containing nine live shells and one case shot; the other with two case shot, and all the articles for firing twelve rounds complete. This mode was found extremely useful in the field, and is strongly recommended for all immediate occasions of service, as no possible mistake can then happen, either from ignorance or neglect, in supplying the guns or limber-boxes with the utmost expedition.

Hand-carts altered to Curricle Carriages.

The ammunition for field service was usually conveyed on camels' backs, each carrying four of the altered 6-pr. packing-boxes[1]—two on each side, in a sort of netted bag thrown over a pack-saddle. But useful as these animals are generally for great weights, there are inconveniences attending them in this particular service, viz., when loaded (which, of course, must be daily repeated) they move very slowly, therefore quite unfit for Horse Artillery. In order to load or unload they must first be made to kneel down, which in an action they are not always inclined to, and sometimes become very refractory and unmanageable. Whatever quantity of ammunition is required for the gun must always be taken equally from both sides at the same time to preserve its equilibrium, &c.

These reasons determined a trial of light carriages in their stead, first beginning with royal howitzer ammunition, it being the most dangerous and liable to injury. Some of the hand-carts were selected for this purpose, and, in order to travel the better, converted to curricles. The poles were accordingly lengthened, and cross-bars fixed to support them in front by the horses' collars, much in the same manner as the 3-pr. carriages formerly used in the Horse Artillery, only more simplified in other particulars, as represented by the drawing, Plate III., Fig. 1. These carriages were drawn by four horses each, and went through all the marches of the Army to and from Grand Cairo remarkably well, travelling very rapidly with the forty-eight rounds of the howitzer ammunition, completed for immediate service, as already mentioned.

Light 3-pr. Carriages altered for Cavalry.

Our Cavalry, from their want of proper horses, being found very unequal to the capitally mounted French Dragoons, it became necessary to aid that defect by the attachment of Artillery. Four light 3-prs. (brought from Malta) were first prepared for this service; their original mode of travelling with shafts and single line of draught was altered to a double one by cutting off the shafts of the limber at the cross-bar, and introducing a pole instead of them, together with other improve-

[1] Sixty rounds complete and four extra case shot over.

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ments, as represented by the drawing, Plate IV.[1] Four or six horses, with two drivers (according to the ground) drew the carriage. These pieces were served by four Artillerymen—two on the carriage, and two mounted on the off-draught horses. They went through the service to Grand Cairo, and travelled much better than was expected from the lowness of the limber wheels, which defect there was no remedy for in Egypt.

Four light 6-prs. upon block-tailed[2] carriages with two royal howitzers were also equipped (as nearly as the means would admit) for Horse Artillery service. Seven Artillerymen and three drivers with ten horses were allotted for the service of each piece—the gunners riding the horses in draught, but the non-commissioned officer mounted single, for the purpose of advancing to examine roads, reconnoitring the enemy, &c.

Ammunition Wagons reduced in Weight.

The success of the curricle carts induced a trial if something might not be done with the wagons also hitherto looked upon as out of all question, except the local duties of the park. Some of them were taken to pieces, and all the heaviest parts laid aside: that is, the bolsters, sides, and shafts. The bottoms were then contracted both in length and breadth, so as just to receive nine or ten of the altered packing-boxes only: the hoops were lowered and the painted covers made to fit exactly. Poles were used instead of shafts, and the usual swingletrees reduced fewer in number, as represented by the drawings, Plate V. The rejected parts being weighed, no less than 600 lbs. appeared saved in the draught by this simple operation, and a larger proportion of ammunition conveyed by it at the same time with less labour. The immense bulk and weight of the devil and platform carriages rendered them totally useless. Some of these altered wagons were substituted as a light class of the latter kind by taking away the bottoms entirely, and fixing in their stead a couple of very strong planks to each, with an interval between them, resembling the original. These light platform carriages proved very useful in withdrawing the ordnance and stores from our lines across very heavy sands for re-embarkation.

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[1] A block of wood (*a*), Fig. 1, was fixed by two bolts to the back of the axletree, and the iron pintail (*b*) removed from the centre of it to this block to receive the trail of the carriage upon. This was done in order to make room for a 6-pr. ammunition box, Fig. 2 (containing 32 rounds complete for the gun), to be fixed crossways in the front; the old side-boxes belonging to the carriage being rejected entirely, their places furnishing seats for two gunners. A small expense ammunition box, Fig. 3 (containing 8 rounds), was made to fit in between the cheeks of the gun-carriage after the French manner. A copper tray or drawer was introduced under one of the gunner's seats to contain the slow match, instead of carrying a linstock.

[2] These carriages, from their lightness, short draught, and quick turning, passed over the inundation dykes and desert with great ease, while the framed carriages, with more horses, were attended with difficulty and delay, and once in the Desert obliged to be left behind.

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Heavy Weights raised without a Gyn.

The two-wheeled trench cart (of which there were, luckily, a number on the Expedition) is a most useful little carriage for conveying articles of moderate bulk to a ton in weight; indeed, even so far as 10-inch iron mortar beds of 23 cwt. were transported in them, but in these cases it was necessary, of course, to make use of a gyn also. To obviate this circumstance, and render the cart (Plate VI.) of more independent utility, an inclined plane (*a*) was attached to the rear of it, and a small windlass (*b*) fixed in the front with a rope and iron block (*c*) hooked to the weight (*d*), having rollers (*e e e*) to ease the purchase, which brings it up on the cart by turning the windlass in the manner shown by the drawings. By this simple means, six men were sufficient to mount upon the cart and deliver at a Battery any article the strength of the axletree could bear, without making the appearance or drawing the attention of the enemy, which such large machines as devil carriages and sling-carts constantly do; besides taking into consideration the vast difference, in point of weight, between these carriages in themselves. Another considerable advantage is, that this contrivance is only occasionally applied, and the cart may be immediately worked in its original capacity.

Narrow Wheels prevented from Sinking in Sand.

It being apprehended that extraordinary heavy weights might cause the low narrow wheels of the trench cart to sink so much into the sand as to retard the draught considerably, a contrivance was thought of to prevent this from happening by occasionally increasing the breadth of the felloes. The staves of casks being strong, and of a favourable shape for this purpose (and still more valuable from their being easily procured at the Commissary-General's Store), it was proposed to cut them into lengths of seven or nine inches each piece, having two small iron staples fixed at an interval the breadth of the felloe. A rope equal in length to the circumference of the wheel is run through each of these lines of staples, secured so as not to slip out, but keep the staves parallel at one inch asunder, as represented in Plate III., Fig. 2. They are then applied to the wheels, as shown by Fig. 3, and fixed by small lashings to the spokes, to keep the whole from any alteration in travelling.

Iron Elevators for Small Mortars.

Previous to the embarkation at Woolwich, six royal mortars were fitted with new beds something deeper but narrower than the old pattern, and open in front. Iron tooth-bars were also jointed to the mortars, for supporting them at any elevation from fifteen to seventy-five degrees, which proved so useful upon service, as to determine the completing twelve more afterwards on the same principle, but rather simpler construction. The elevator was here reduced to a common flat bar, as represented in the drawing, Plate VII., Fig. 3, with some square

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holes pierced through to receive a strong bolt, which the mortar resting upon is supported at a certain number of points of principal elevations.[1] The other end of the instrument is fixed to the bed by a common iron staple only, quite independent of the mortar, without collar or joint, which in the former ones were found to be attended with some inconvenience.

Landing 24-pr. Guns from Flat-boats.

Many of the flat-boats being much injured by these great weights resting upon the gunwale during part of these operations, particularly on shallow beaches, an inclined plane was constructed (at Aboukir, with legs instead of the usual spars), which was placed close to the boat, in the manner seen by the drawing, Plate VII., Fig. 2, and thereby took off the strain from it at once. The plan was much approved of by the Navy Officers that used it; but, unfortunately, having nothing stronger than fir platform sleepers to work upon, it was soon rendered unserviceable. The plane was about sixteen feet in length, the height equal to that of the boat, when near touching the ground. If it should be found more convenient to have it shorter, in order to render it lighter, a couple of spars might be added, extending to the shore, as represented by the drawing.

Return of Ordnance Captured in Egypt.

In the Field ...	The 8th March	5
	" 13th "	3
	" 21st "	2
	" 22nd August	7
Garrison ...	Aboukir Castle	11
	Fort Julian	15
	Fort Burlos	5
	Grand Cairo and Dependencies	121
	Gizeh Lines and Arsenal	530
	Alexandria "	411
Island of Marabout		10
Damietta, and Walls of Lesbie, &c.		54
Ship of War in the Harbour of Alexandria		77
Total number of Pieces ...		1251

N.B.—Besides the above, the French were allowed to embark 50 field-pieces from Cairo, and 10 from Alexandria.

Some Observations on the foregoing Articles.

1st. The original intention of the Expedition did not appear to have Egypt for its object, and for a considerable while was very inauspicious.

[1] 10, 15, 20, 30, and 45 degrees. Any intermediate ones for particular occasions may be observed by placing a wedge between the mortar and elevator.

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In the first instance, it proved too late to be any use to the Austrians in Italy, and afterwards became unsuccessful at Cadiz. Much time appeared to be lost before it reached the rendezvous at Marmorice Bay, and it was then thought by the Turks a very unreasonable part of the year for any attempt on the coast of Egypt; besides which, it happened to be the time of their Ramasan, when no operations of any kind are undertaken by them. This last delay however, though much regretted, turned out advantageous to the future proceedings of the Army. Some useful arrangements were made there, besides the opportunity it gave of landing the sick, after a long confinement aboard ship, by which many recovered, and the Island of Rhodes, just in the neighbourhood, afforded hospitals for the remainder.

2nd. All the field ordnance which had been landed at Ferrol with Lieut.-General Sir James Pulteney's Army, and afterwards joined General Sir Ralph Abercromby, were re-embarked there in so disorderly a manner—no one piece was found fit for immediate service. This circumstance will for ever unfortunately occur, unless the direction of the business be left entirely to the Artillery Corps, whether Navy boats and Ships of War, or those of the Ordnance only receive them. It cannot be expected that the Navy Officers are, in the first place, fully acquainted with the real importance of keeping all the parts of such carriages, ammunition boxes, &c., exactly sorted together, or that they can bestow much consideration on the subject, hurried as they generally are upon such occasions.

3rd. The turning over only rejected horses from the Dragoons to the Artillery Service, was not so well judged as might be expected. It would have been fortunate (the best of theirs bearing no comparison with the French Cavalry) to have rendered the movement of the ordnance more effectual—as it was, both Corps remained insufficient—the effects of which were fully experienced in the action of the 13th March, when, had only a part of the number of pieces then in the field been very well horsed, the fate of Alexandria, it is more than probable, might have been decided on that day. The French, on the other hand, constantly applied the very prime of their strong horses (those belonging to the Officers not excepted) to the draught of their ordnance, which were chiefly on the Horse Artillery establishment with 8-pr.[1] guns and 6-inch howitzers, opposed to light 6-prs. and royals only.

4th. The disembarking of ordnance, unless in the instance of field-pieces let down into the boats, ready mounted from Ships of War, however regularly performed, is always liable to some confusion. This principally arises from the parts of the same natures of carriages not corresponding so correctly as they might do, particularly in the diameters of the wheels and arms of the axletrees, which should, likewise, be as

[1] Equal to British 9-prs., and howitzers as 4 to 3 in proportion.

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general throughout the whole as possible.[1] The wagons and carts, being frequently made by contract, are very defective in these points, even to the fitting of their head and tail-boards; and trifling as this may appear to a workman at home, often occasions delays of consequence to the Service, or credit of those concerned in it abroad. No nation, in point of economy alone, requires so much attention to the construction and solid stowage of its military carriages and stores as Great Britain does, on account of their frequent embarkations, the expenses of which, in the course of a war, are prodigiously great.

5th. The considerations submitted to the Commander-in-Chief, respecting the first landing of the ordnance and stores, were much approved and happily executed with great dispatch, notwithstanding some very serious impediments, arising from the manner of loading the ships by freight (carrying as much as possible without order), instead of being regularly assorted. The embarking troops, also, aboard such ships is always attended, with not only great inconvenience, but considerable damage, from the quantity of water necessary to carry for them, the waste and leakage of which injures the carriages and stores considerably underneath, besides the difficulty it occasions of getting at them when required for service.[2] Great inconveniences were found, also, from the magnitude of some of the ships, which could not be brought within some miles of the shore. They should, for such services, never exceed 300 tons and a moderate draught of water.

6th. Carronades might certainly be employed in the land service to considerable advantage in many situations, particularly on the flanks, or firing over the parapets of fortifications, and for field-works in general. It would also be very well worth while to have some experiments tried with them in breaching walls and earthworks. The common objection made to their shortness injuring the embrasures has more of imagination than reality in it: they may be advanced the extent of any gun mounted upon a travelling carriage, and much further than the largest garrison howitzer, with less explosion of powder. If their present carriages are found to recoil too far, it is easily checked, by only laying a few filled sand-bags upon them and in the rear, as was practised in Egypt with perfect success; or it may be checked by small iron wedges, with chains placed to receive the fore-trucks upon, as seen in the drawings.

7th. The arrangement made of the spare field ammunition on the passage from Marmorice Bay to the coast of Egypt was very fortunate, as it proved impossible to have carried any quantity forward otherwise, for want of conveyance, excepting a few camels taken from the enemy on the first landing in Aboukir Bay.

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[1] The arms of the axletrees and diameters of the wheels of all carriages immediately connected with each other on service should correspond exactly: that is, the gun and limber, ammunition wagon, and large carriages perfectly alike in their particulars.

[2] In the preparations for landing at Cadiz, seventy tons of water were obliged to be first removed from one ship only.

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8th. The 3-pr. light guns, patched up as they were,[1] gave considerable confidence to the Dragoons. This calibre might be rendered very useful to Cavalry in general by an increase of dimensions—to four feet and half in length and about four hundred in weight—with carriages upon a quick travelling construction, not over-loaded with ammunition, which our Service is rather liable to. Foreigners frequently observe the singularity of shafts being preferred in the British Artillery carriages to poles—made use of by all other nations, as being simpler, lighter, and cheaper; added to which the experience of having travelled over the most difficult features of Europe, and grounds of every description with them, fully evinces their perfect efficiency. A strong instance of the inconvenience of shafts occurred to us at Ramanieh. Just as one of the 6-prs. was limbering-up, the shaft horse was killed by the enemy; much time was lost in clearing the carriage from him, and the thill harness being also damaged rendered it difficult to apply another in his place. In the marching of the 12-prs. to Grand Cairo (drawn by oxen with a horse in the shafts),[2] the want of double or travelling trunnion-boxes were much regretted. Some few carriages were formerly so constructed for the Horse Artillery, but why discontinued remains unknown, as they are undoubtedly very advantageous to a heavy draught or indifferent horses. In moving the 24-pr. guns across the country from the first position near Cairo (where a bridge of boats to communicate with the Grand Vizier's Army was thrown over the Nile) for the attack of Gizeh, the axletrees of the sling-carts giving way, the medium 12-pr. carriages were appropriated to this purpose, the trench carts carrying the mortars, standing carriages, &c.

9th. No carriage appears to want reform more than the common Artillery wagon: there is too much of it merely for carrying ammunition, and it is too narrow for baggage or bulky stores. In the alterations made for the proposed arrangement of spare ammunition, the boxes will require, for hard roads, to be more securely fixed than was necessary for travelling in Egypt.

10th. The inclined plane, or purchase, for raising weights upon the trench-carts, might prove very useful upon a larger scale for mounting and dismounting heavy ordnance without being obliged to make use of a gyn, which not only requires a number of men to work, and a carriage to convey it to a Battery, but, when fixed there, becomes a considerable object to the enemy besieged. This proposed machine, being quite free from all these inconveniences, makes it extremely well worth while to try the experiment for such occasions.

11th. If the mode mentioned of preventing narrow wheels from sinking in deep sandy situations should have the appearance of possessing more fancy than judgment, it must be placed to the variety

[1] It may be worth observing that the usual sweep-bar (supposed to be inconvenient to the limbering-up and unlimbering) was entirely omitted, and found quite unnecessary.

[2] The oxen drew very well upon common ground, but in deep sand generally became restive. The large-sized mules were excellent in draught when well-disposed, but from their natural obstinacy it was found best to intermix them with horses.

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of obstacles which hourly presented themselves in Egypt, and called for every assistance the mind could catch at to surmount! And still, perhaps, the idea may lead to something useful even in a northern climate, passing over snow, &c.

12th. The elevating instruments for small mortars, as constructed upon the Expedition is so very simple, any blacksmith can make them in the field as at a regular field-forge. They rendered the mortars very useful in the capacity of howitzers at the Attack of Aboukir Castle, and are applicable to them, as far as the 8-inch calibre: but for those of ten and thirteen inches diameter, whose beds have more space and greater weights to support, quoins are preferable. The extraordinary heavy weights of the iron mortars and beds proved a great embarrassment, without any peculiar advantage derived from them. Indeed, where no considerable extent of range is required (as is the case in most attacks), brass mortars, mounted upon proportional iron beds, seem in general much preferable, at least under thirteen inches in diameter. The iron trucks of the 24-pr. carriages were found, besides their great additional weight, to tear up the temporary platforms very soon. Wood ones for such occasions should be used on both these occasions. Cap-squares to heavy garrison carriages are quite unnecessary, and, when fixed by jointed bolts, particularly inconvenient in mounting and dismounting the guns, as well as in point of stowage aboard ship. Most other nations have them only secured by keys or hooks, or omit them altogether.

13th. Flat-boats are the best and most useful conveyance for troops and ordnance possible. Every means, therefore, should be employed to preserve them from injury: though apparently slight, it is surprising what they can bear. In moving the stores up Lake Etcho for the Attack of Fort Julian, some of them were dragged three miles over sand and mud-banks. The battering-pieces for this service were obliged to be landed on the open sea-beach, and conveyed four miles across the Desert and swamps to their batteries. These laborious and difficult operations were frequently repeated during the Expedition. Upwards of thirty 24-prs. were disembarked from the ordnance ships, conveyed by boats up Aboukir Lake, and landed near the head of it, for the Attack of Alexandria.[1] From thence, twenty were returned to the ships in Aboukir Bay, conveyed to the mouth of the western branch of the Nile, disembarked and taken over that dangerous bar by sea-jerms, landed at Fort St. Julians, re-embarked there in river-jerms, in order to proceed up the Nile. Several of them were landed within four miles of Grand Cairo, and conveyed from thence twelve miles across the country for the Attack of Gizeh; returned back after the surrender of Cairo by the same route, and exactly in like manner to Alexandria, re-landed there for further operations of attacks, carrying on both on the eastern and western side of it—the capitulation of which concluding the Campaign—they were again conveyed to the ships in Aboukir Bay.

[1] Seven 24-prs. were employed against Aboukir Castle previous to this operation.

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Besides the articles already detailed, numerous minute circumstances happened in the course of the Campaign which necessity continually urged the imagination to provide against. Every movement by land or water was attended with infinite labour and difficulties: added to which, the violent heat of the sun, and shocks received by passing over the formidable cracks it occasioned in the ground (annually overflowed by the Nile) on the march to Cairo, operated so powerfully on the carriages as to require perpetual attention and daily repair, without the most common materials for such occasions, either of wood or iron, to be found in the country.

Rock Mortars.[1]

These are excavations resembling the interior of mortars, formed out of solid rocks, of which there are several in the Island of Malta, executed upon a large scale for the defence of the harbours, &c.

Having heard much of this species of Artillery, it excited a curiosity (in our return from Egypt) to experiment two of the most perfect, which are situated in St. Julian's and St. George's Bays. The drawing (Plate VIII) represents a section of one as loaded and fired on the 24th February, 1802.

1st. At St. Julian's—140 pounds of powder was enclosed in a sort of cask prepared to fit the chamber of the mortar, and being lodged there, a large cane tube filled with quickmatch, was applied to a groove cut along the upper surface of the bore to receive it, and a bottom of wood covered the chamber. The stones were then piled, by four men, within the mortar as they were brought to it in baskets containing about 120 lbs. each: a dozen stones weighing from 120 to 80 lbs. each were first put in, then fifty baskets of other stones from 60 to 30 lbs., then fifty more of 20 to 5 lbs. each, amounting in the whole to upwards of 10 tons. This operation being completed, a piece of portfire was fixed to the end of the tube at the mouth, which communicated through a hole in the cask to the powder. In this manner it was fired as is usual in proving ordnance, and ranged about 700 yards.

2nd. The same mortar was loaded with 180 pounds of powder, and about 10 tons of stones; they spread considerably more than the first time, but did not range quite so far. The explosion this time cracked the mortar in a direction nearly vertical, leaving a fissure in the rock about one-twelfth of an inch wide, ten feet in the rear and four feet in front.

3rd. The other mortar of similar dimensions was fired with a charge rather larger than the first of these, but the effect was not quite so considerable: from whence it is concluded that the first proportion should not be exceeded, especially if after repeated. The stones used in these experiments were chiefly fragments of the rock, which having been exposed to the air were become something harder, and did not suffer so much as might be expected from such violent explosions, which in some degree resembled the tremendous discharge of a volcano.

[1] A small one upon this principle was executed at Gibraltar in the year 1770, in the form of a parabolic conoid (without a chamber) calculated to throw about 1500 lbs. of stones.

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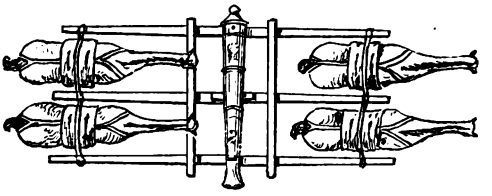
FIG. 2.



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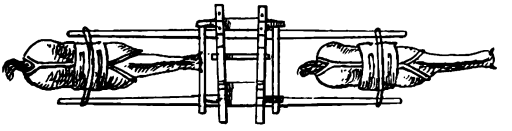
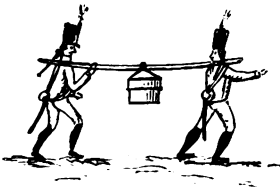


FIG. 3.



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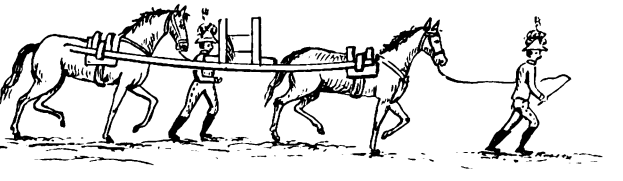

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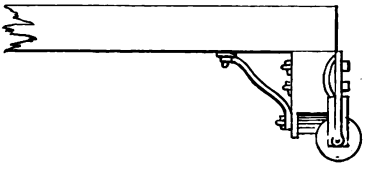
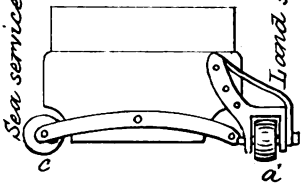
PL. II.

FIG. 1.





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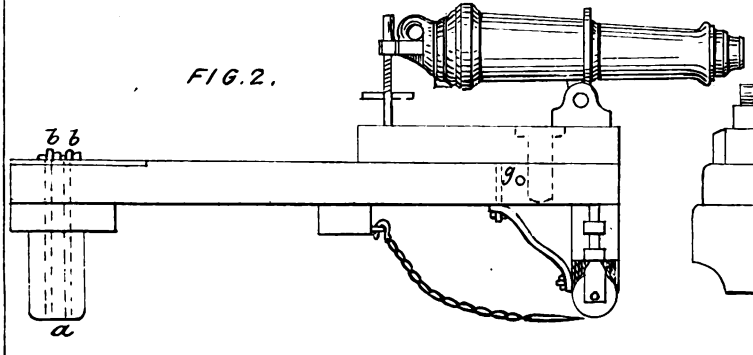

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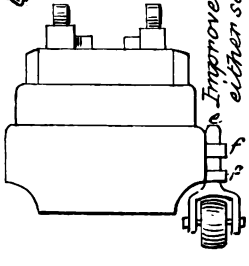

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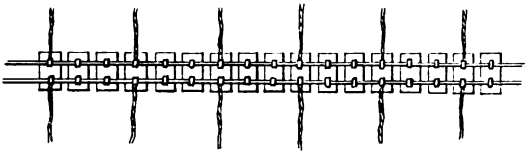
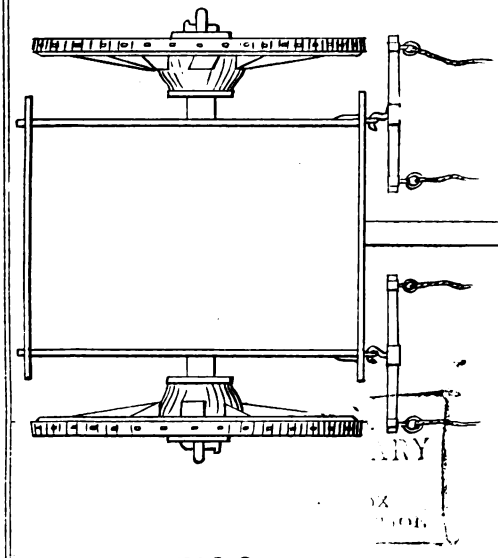
FIG. 2.





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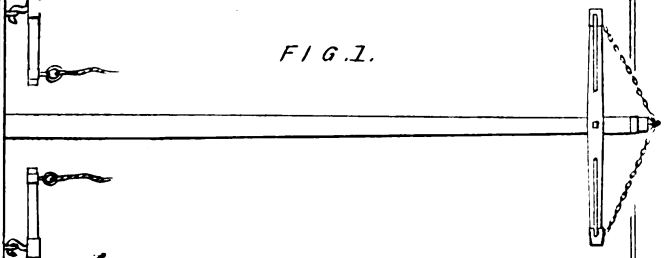

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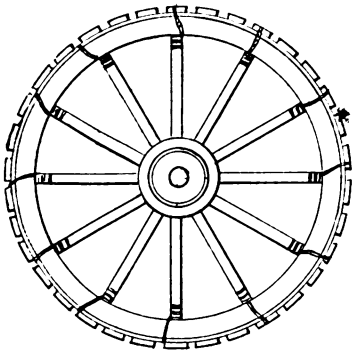

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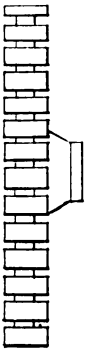

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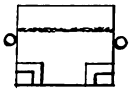
FIG.3.



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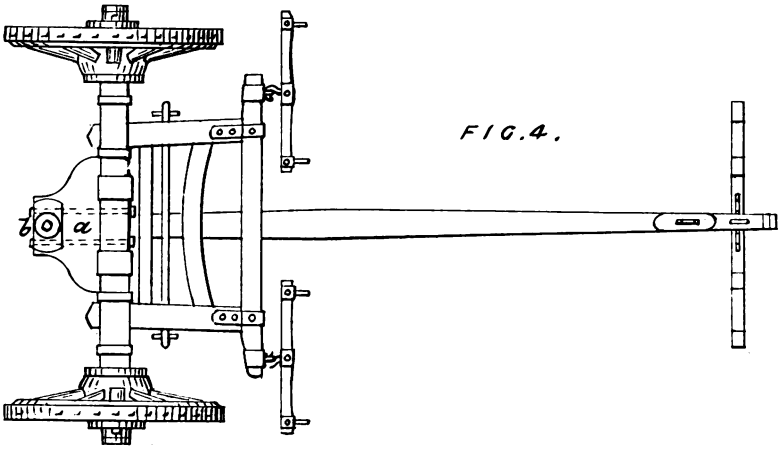
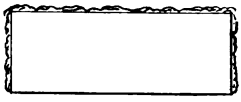


FIG.4.

FIG.2.



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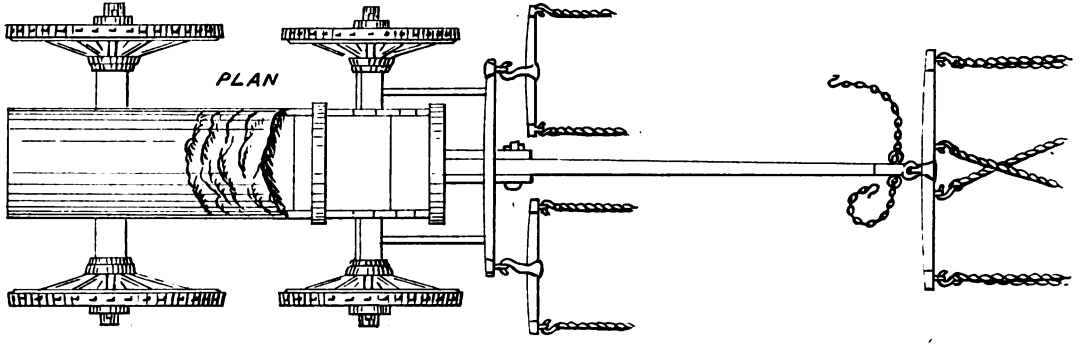
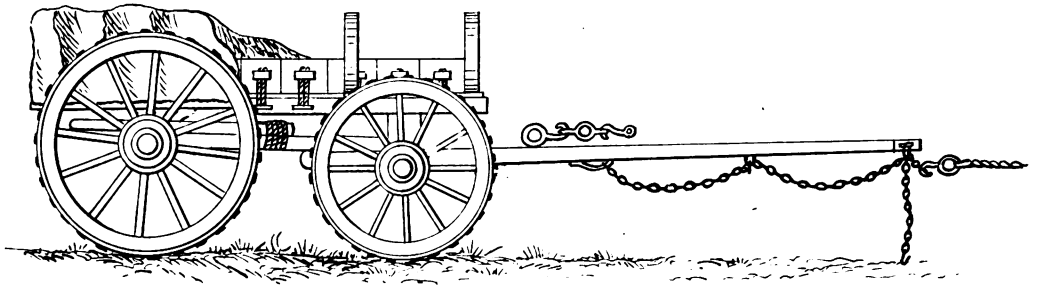
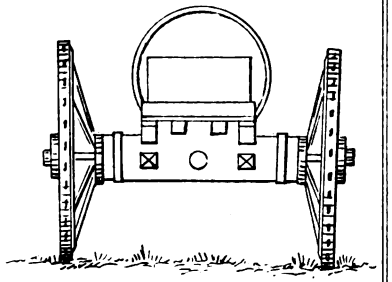


ELEVATION





HIND ELEVATION.

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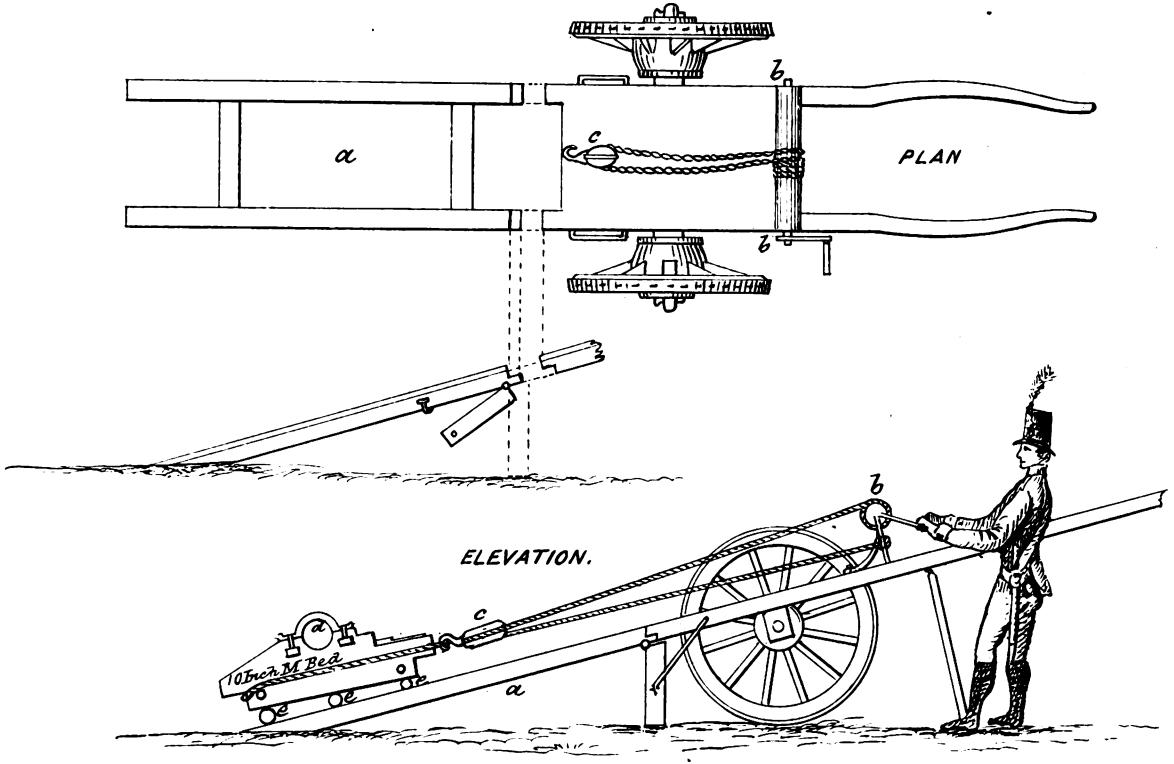

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FIG. 1.

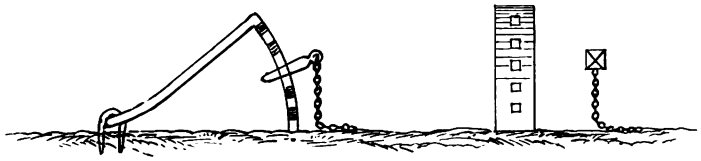


FIG. 1.

Section of mortar with the elevator.

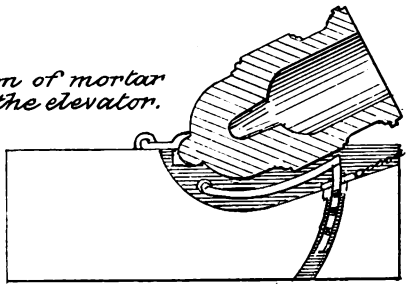
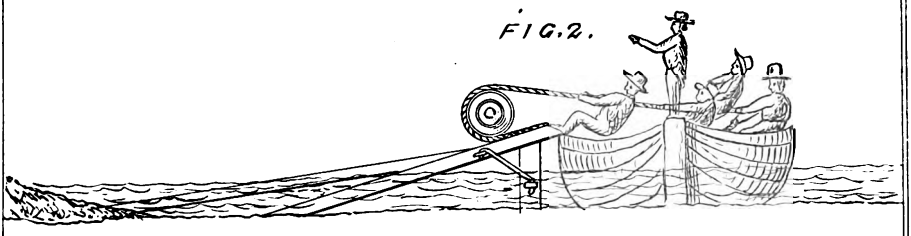


FIG. 2.



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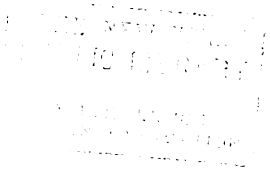

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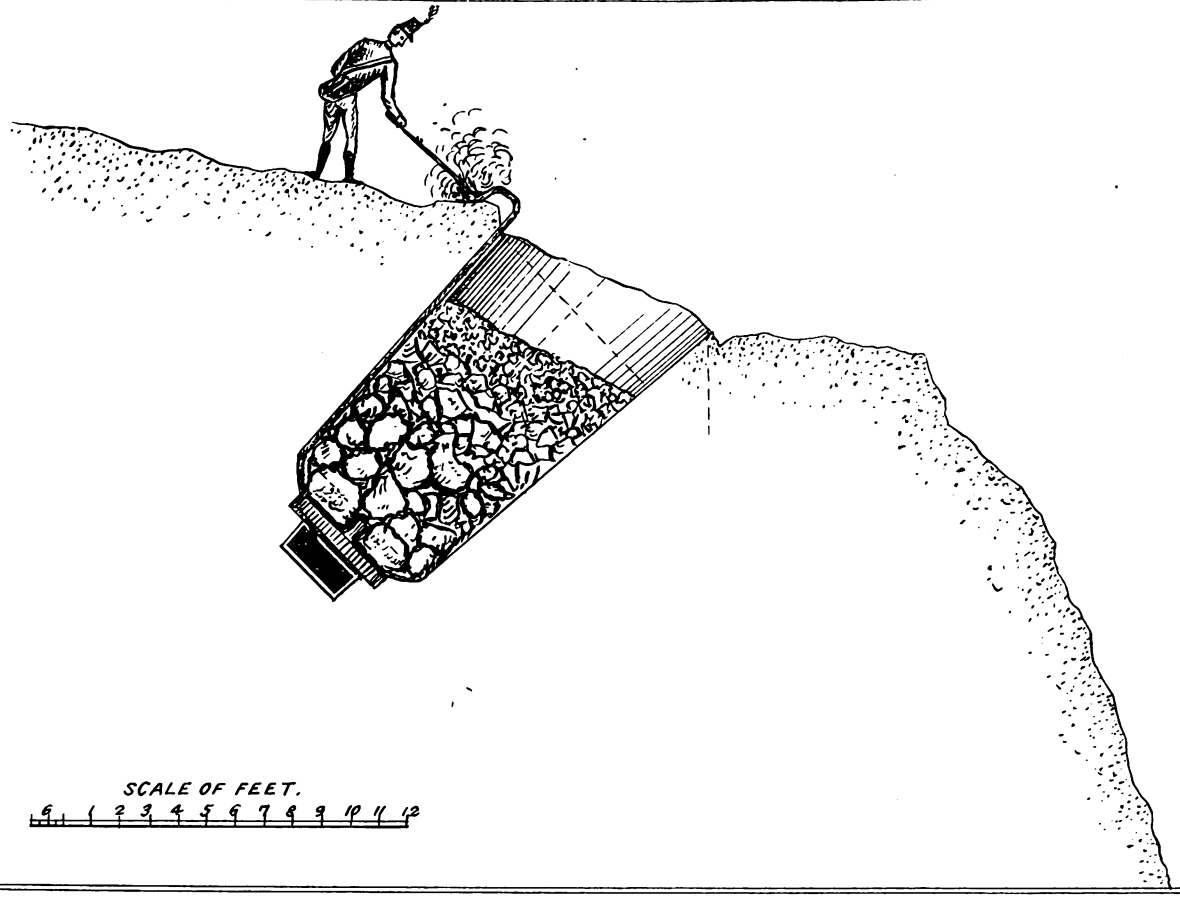

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NOTE

ON

PERCUSSION FUZE USED BY EGYPTIANS

WITH

KRUPP GUNS.

BY

CAPTAIN E. F. BECHER, R.A.

ALTHOUGH there is nothing new in the following note on the Percussion Fuze used with common Krupp shell by the Egyptians; yet it may be useful to some of my brother Officers who may have to bring a Krupp gun into action at some future time. On the surrender of the rebel Egyptians at Kafr Dwar, I was sent with a detachment of the Royal Artillery by order of Sir E. Wood, to prepare for action a Field Battery which had been left there, as it was possible that we might have to work it. If it had not been for the civility of an Egyptian Captain of Artillery, who took great pains to explain to me how to prepare the shell, it would have been difficult to discover the method.

The projectiles in the limbers and wagons are case shot, common shell and segment; the fuze hole of the latter is of a larger gauge than that of the common, and fuzed with a metal time fuze, apparently of Egyptian manufacture. The common shell are packed with plug (Figs. 1 and 1*a*) inserted; if the plug is removed by means of a key and the shell inverted a loose pillar (Fig. 2) will fall out: a thin metal cylinder (Fig. 3), acting as a wad, is then seen.

FIG. 1.

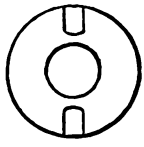


FIG. 1*a*.

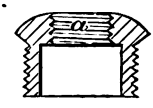


FIG. 2.

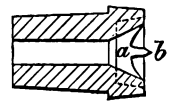


FIG. 3.

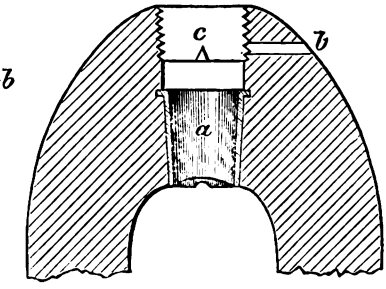


FIG. 4.

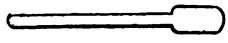
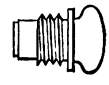


FIG. 5.



The number who prepares the shell wears a pouch fitted inside with wood, in which are holes for a certain number of pins (Fig. 4) and

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detonating caps (Fig. 5). The plug (Fig. 1) is simply a hollow cylinder, the head being tapped to receive the detonating cap which is screwed in at *a*.

The pillar (Fig. 2) is also a hollow metal cylinder with a small piece of gunmetal, on which is a small coarse spike of the same metal slotted in across the head. The wad is a thin metal cylinder with a shoulder at the top, and closed at the bottom with the exception of a round hole in the centre covered with gauze.

To prepare the shell the number wearing the pouch takes out a pin (Fig. 4) and inserts it in the hole in the head of the shell (*b* Fig. 3); he then screws the detonating cap (Fig. 5) into the head of the plug (*a* Fig. 1*a*) and the shell is ready. On reference to Fig. 3, the position of the needle point on the pillar (if inserted) is shewn at *c*: the safety-pin keeps the pillar from moving forward, and thus exploding the shell prematurely.

Care must be taken that the head of the safety-pin is always upwards, otherwise it might drop out. The shell is inserted in the bore, so that the safety-pin is vertical—head naturally upwards.

Action.—On leaving the bore the rotation of the shell brings the safety-pin into a position so that it can fall out on impact, the spike on the pillar striking the detonating composition on the cap.

The common shell for the 15^{cm} gun (no other description of shell was observed) were all fuzed with this fuze.

MALTA,
23 October, 1882.

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THE LINES OF KAFR DWAR.

BY

LIEUT. G. H. McLAUGHLIN, R.A.

On the day of the reported surrender of the Kafr Dwar Lines nothing of much interest occurred. It was said the rebels were endeavouring to obtain some terms, but that Sir Evelyn Wood would hear of nothing short of unconditional surrender, and that to the British Troops and not to the Khedive only. However, on Saturday, the 49th and 53rd were ordered forward from Ramleh, the latter Regiment having two Companies under Major Rooke at the first line of earthworks. A detachment of 30 rank and file of 5 Battery, London Division, commanded by Lieut.-Col. W. H. Graham, was also ordered to proceed from our post on the next day (Sunday) to take charge of the Artillery in the works and (at a time to be afterwards fixed) load the guns on trucks, with wagons and limbers, and send the whole to Alexandria, a distance of some eight miles. I was sent in charge of the party, and so had a good opportunity of observing the lines while Egyptian soldiers were still in them, although by the time we arrived many of the rebels had disappeared, leaving their arms, tents, &c., behind them.

The main portion of the earthwork consists of a parapet extending from the canal to the railway, a distance of some 200 yards. The parapet is of the following profile:—Command varies from 50 to 30 feet, and has an exterior slope rather steeper than $\frac{1}{1}$, the thickness at crest being about 30 feet. The interior slope is perpendicular, and about 8 feet to 9 feet high; the gun terreplein about 27 feet in width, quite level and hard to walk upon; and then a slope to the rear of about $\frac{1}{1}$, intersected with ramps having a slope of about $\frac{1}{3}$. There is a wet ditch in front fully 75 feet wide.

Between the canal and railway there were 10 gun embrasures for 8^{cm} Krupp guns, and one for the big 15^{cm} gun, with guns in each. There were four magazines, but each gun had a small expense magazine built by it. The dimensions of these magazines were about 5 feet high by 9 feet long by 5 feet wide, but we found ammunition in one only, namely, that which supplied the big gun, and in this were only 46 rounds which one of the Egyptian Officers told me was all they had for that gun in Egypt. This was the gun which had effectually checked the advance of the armoured train, and had dropped common shell with percussion fuzes, both close to this camp and the camp at Ramleh. We had thought that there was not much ammunition for

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it, as they were very chary of firing this gun; but no one suspected how very little there was.

The gun, which looked like one of our 40-pr. B. L.'s considerably thickened, fired a 60 lb. projectile with 13 lb. of prismatic powder, and the muzzle velocity is shewn in Handbook for Field Service, '78, as over 1600 f.s. It was mounted on a travelling carriage, which gives it a power of firing over as high a parapet as our overbank arrangement. The carriage is simply an iron framework on wheels, having a heavy trail, which is pierced to fit on to the pin of a limber, and has a step which becomes horizontal when the gun is ready for action. To check recoil there was an arrangement like a patent English carriage brake, and two very large quoins which were placed behind the wheels. The platform was composed of stout planks sunk into the earth, not pinned down in any way, and was about 20 feet × 15 feet. For the 8^{cm} guns there was in each emplacement a kind of rudely constructed Clerk's platform, with a small ditch sunk for the trail. All these guns were in thoroughly good working order. Our gunners seemed much impressed by the simplicity of the breech arrangement.

The limbers and wagons were parked in a line below, and in each gun limber there was a clinometer, an instrument that might have been of some utility with our 12-prs. if we had had one.

It may be worth while to note that we had considerable trouble in getting the wagon bodies of these Krupp guns on to railway trucks, as when the wagon body is separated from its limber the wheels bear only a small proportion of the total weight, the principal part being at the point of the perch, which is too short for a sufficient number of men to work at. This is caused by two large boxes being placed with their centre of gravity considerably in advance of the axletree bar, and also by a heavy iron box which is fitted on to the perch. There was indeed the greatest trouble in packing, loading, and removing the limbers. As soon as the pole was removed for packing purposes, the limbers showed a strong tendency to overturn, which it was very difficult to overcome owing to there being no splinter-bar.

The line of earthwork referred to crossed the railway line and extended about 20 yards beyond it. On the railway itself had been constructed a regular masonry gun emplacement for a 7-inch Armstrong M. L. gun, *en barbette;* and we found the gun itself, which had not been put in position, ready on a truck just in rear.

After passing over the railway, the parapet terminated in a large mound of the same profile as the main parapet, and it seems that it was intended to continue this line of work still further, perhaps as far as a small square redoubt about 400 yards away on the extreme left which had embrasures for field guns, and a parapet for musketry fire. This fort was absolutely in the swamps of Lake Mareotis, and would have been very useful in flanking the main line.

On the right of this main line was the Mahmondieh Canal (pronounced Mahmond*eeyeh*), and about 30 yards in rear of the line was the big dam over the canal. This dam was about 120 feet broad at the water line, and was built above in the form of a parapet for musketry fire,

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but having embrasures for three field guns. The dam was continued in a parapet on the further side of the canal for about 25 yards and then it abruptly terminated. This short line of work was also intended for musketry fire from the parapet, and was pierced with embrasures for four field guns.

In front of the whole line between the railway and the canal were a series of shelter trenches at about 200 yards interval. In rear of the main line, at a distance of about 250 yards, was an enormous traverse about 45 feet in height, 30 feet in thickness at crest, the sides having the natural slope of the earth about $\frac{1}{1}$. It would seem that it was never intended to convert this into a position of Active Defence, and we found in rear of it, a large number of horses, tents and stores. So much for the main line, which was estimated at about 6,250 yards from our posts at Ramleh and Antoniades.

The position was continued along the canal banks for about 2000 yards towards Ramleh, and the direction of the canal is only about 15° out of a direct line with Ramleh. It terminated in the Rocket Battery, where there where two Batteries of field guns; and evidently a strong advanced picquet had been there, for we found their arms in a heap as they had left them.

The canal banks were eminently suited to being turned into a line of defence, and at frequent intervals embrasures had been cut to admit of field guns being fired in case of a retreat or an advance between main line and Rocket Battery. The guns at Ramleh could not enfilade this line, and our Artillery were unable to take up any position which could effectively have done so, as the prolongation of the line falls on a low-lying plain some feet below the level of the Rocket Battery, which was also protected by a clump of palm trees.

From this brief account it will be seen how very strong were Arabi's first lines; his right flank completely protected by Lake Aboukir, his left flank resting on Mareotis, the ground in front being low, and affording no cover for advancing troops, while he had a large number of field guns and horses, with a railway in rear to bring supplies right up to the works. Both the lakes referred to are so shallow that no gun boat or even steam launch can approach.

As regards the finishing off and detail of the works, nothing could have been better done. The interior slopes, sides of embrasures, &c., which were perpendicular, were revetted to a thickness of about six inches with a compound of chopped straw and canal mud, such as the walls of all Arab huts are encased in; and from having had to superintend the demolition of some of these huts, I can testify to the extraordinary tenacity of the mixture.

The defences were continued back in two more lines as far as Kafr Dwar; the second line consisted of a lunette close to the canal with a shelter-trench continued to the railway; and the third and last line had two redoubts, one on the canal banks and the other close to the railway, connected by a well constructed shelter-trench. The second line was roughly about 4000 yards in rear of first line, and the third line about 1500 yards in rear of second. All the redoubts had wet ditches. It will be seen that it would have been almost impossible to have

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carried the first lines against good troops by direct assault, as our advance for nearly the whole distance from Ramleh would have been over a flat low-lying plain (under a heavy Artillery fire) without a scrap of shelter, though of course an attack at daybreak would have obviated a portion of this difficulty.

From what one can gather from the Egyptians, they seem to have been altogether unprepared for the landing of the main body of the Army at Ismailia; perhaps they had been deceived by M. de Lesseps, who it appears had given them to understand that we could not do so without violating some treaty. Certainly they kept their best troops at Kafr Dwar, and these on hearing of the brilliant success at Tel-el-Kebir, and understanding how useless their defences were against an attack from the rear, thought surrender the only thing left. In connexion with the enormous amount of labour and the consequent expense involved in raising such works as these, I asked a Captain of the Egyptian Artillery, who was a prisoner in the works, if the Arab workmen, of whom there were thousands, had not cost a deal of money. "Oh no," he replied in French, "we don't pay them." But, I said, their feeding alone must have been very expensive. "No," he said, "we don't feed them;" and it turned out afterwards that they brought what they could from their homes, and then lived on any beans or Indian corn that could be got in the fields around. The overseers, with a good stout cane, managed the rest.

ANTONIADES POST,
NEAR RAMLEH, ALEXANDRIA,
SEPTEMBER 22ND, 1882.

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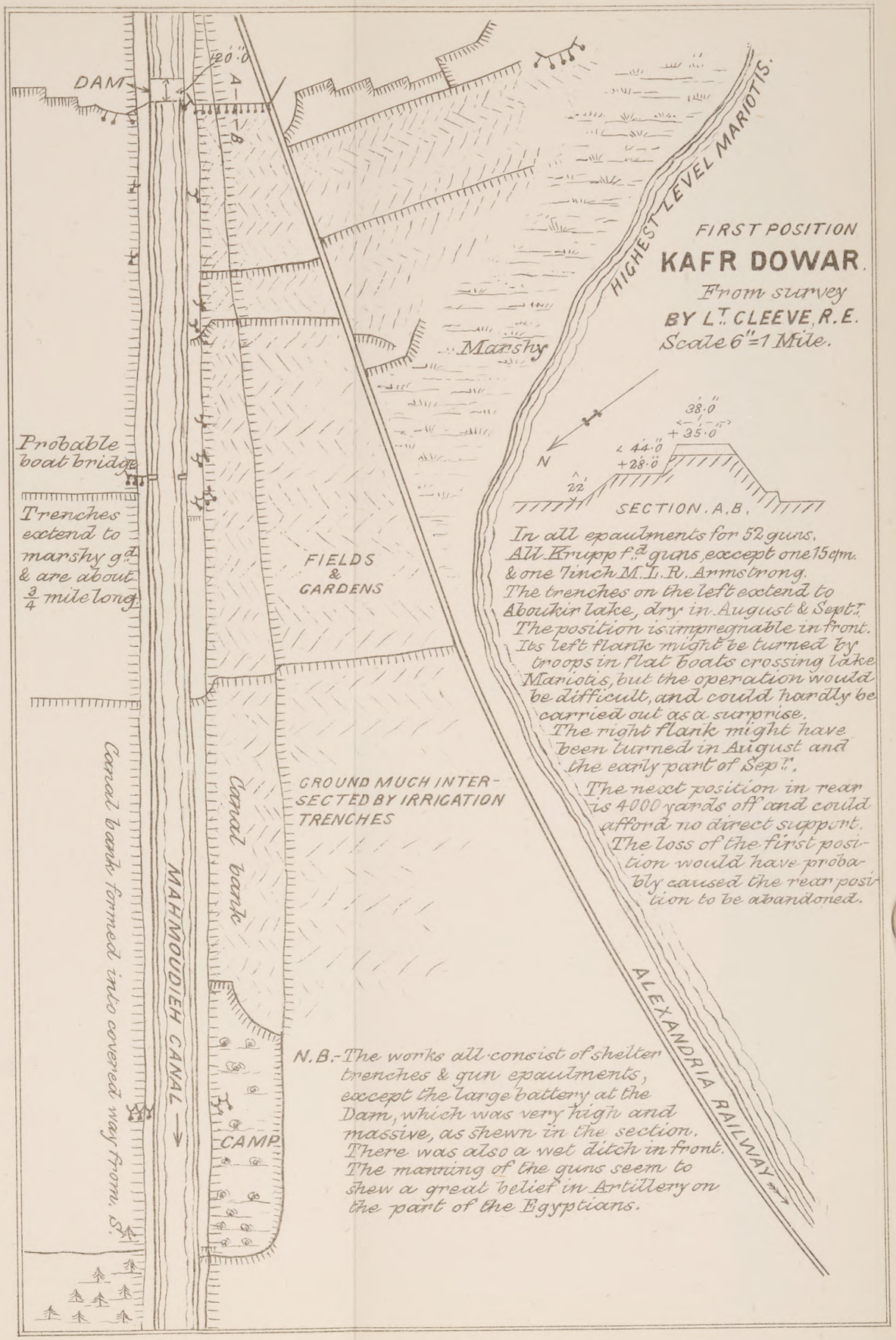
DAM
20·0"
A
B
Probable boat bridge
Trenches extend to marshy gd & are about ¾ mile long
FIELDS & GARDENS
Marshy
HIGHEST LEVEL MARIOTIS.
FIRST POSITION
KAFR DOWAR.
From survey
BY Lt CLEEVE, R.E.
Scale 6"=1 Mile.
38·0"
+35·0"
∠ 44·0"
+28·0"
N
22°
SECTION. A.B.
In all epaulments for 52 guns.
All Krupp f.a guns, except one 15 cm.
& one 7 inch M.L.R. Armstrong.
The trenches on the left extend to Aboukir lake, dry in August & Sept.r
The position is impregnable in front.
Its left flank might be turned by troops in flat boats crossing lake Mariotis, but the operation would be difficult, and could hardly be carried out as a surprise.
The right flank might have been turned in August and the early part of Sep.r.
The next position in rear is 4000 yards off and could afford no direct support.
The loss of the first position would have probably caused the rear position to be abandoned.
GROUND MUCH INTERSECTED BY IRRIGATION TRENCHES
Canal bank formed into covered way from S.
MAHMOUDIEH CANAL
Canal bank
CAMP
ALEXANDRIA RAILWAY
N.B.- The works all consist of shelter trenches & gun epaulments, except the large battery at the Dam, which was very high and massive, as shewn in the section. There was also a wet ditch in front. The manning of the guns seem to shew a great belief in Artillery on the part of the Egyptians.

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THE ASSAULT ON THE REDAN,

BY

GENERAL S. E. GORDON, C.B.

A FEELING approaching to indignation is periodically raised in some of us when, from time to time, we read paragraphs touching upon our shortcomings, as connected with the part taken by our soldiers in the final assault when the southern side of Sebastopol fell into our hands through the retention of the Malakoff by the French.

The following paragraph in the excellent treatise of my friend of 40 years, who won the Gold Medal of the R.A. Institution for the second time this year, appears in page 121 of the Proceedings :—"It "is probable that—if, at the last, the operation of mounting five of the "heaviest guns which were intended to reduce the flanking defences "of the Great Redan, and so prepare it for the impending British Assault, "could have been achieved instead of miscarrying entirely on two "succeeding nights—the British columns would have reached the "interior of the work in such order as to have been able to maintain "themselves there . . . and the credit of the British Arms "" . . . would have taken a higher place in history than it owns "to day."

On reading this paragraph, all the declamation of the Press, all the clamour raised at our supposed failure (more than hinted at again above) were recalled to mind, and raised the feeling of indignation at the injustice done to our brave soldiers who took part in that assault, and has induced me to strive to bring more forcibly before our Corps at any rate, the real state of the case, and thus show that so far from failing, our gallant Infantry succeeded in what it was intended they should do, in the face of a necessitated departure from an accepted axiom, that an assault given by besiegers before the trenches are brought close up to the breech invites failure; and consequently we have reason to glory in the true records of the event of 8th September, 1855, instead of taking the low place said to be assigned to us "in history" by the paragraph above quoted, and by writers who either have ignored the facts of the case, or are unacquainted with them.

My object in writing is in no way to criticise the very able essay of Colonel Smyth; for I entirely agree with him in his remarks on the want of power of the R.A. during the siege, chiefly from paucity of men but partly also from the want of previous education and instruction in the hard-worked Artillerymen who earned such glory in the trenches.

The circumstances connected with the final assault are depicted in the Note of the General Officers R.A. and R.E. given below and the action taken thereon.

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The Note (which it happened to be my duty to have to translate from the French some days before the assault), was accepted by the Generals Commanding-in-Chief: it should be carefully read that the *purpose* for which the several columns of assault were launched may be fully understood. A rough sketch is attached to enable readers to acquaint themselves with the position of the several works alluded to.

Attention is particularly called to that portion of the Note printed in Italics, because it shows clearly the following points:—

1. The great object of the Allies was to obtain possession of the Malakoff, and—
2. With a view to retain the Malakoff *after* it was in possession of the French, assaults were to be made by the English on the Redan, and by the French on the defences on the Town, to prevent the enemy massing their troops to recover the work; the retention of which by the Allies would render "the fall of the Karabilnia suburbs inevitable."

NOTE.

"The undersigned having met in pursuance of the orders of the Generals-in-Chief are of opinion that the labors of the Siege have reached such a point that the assault should take place without delay; the considerations on which they found their opinions are these—

"In the attack of the Town the works have remained for a long time stationary; they cannot be pushed further without great loss.

"Before the Redan, the English have made some progress but cannot push further without great difficulties, which would entail serious impediments to the attack.

"Before the fort of the Malakoff the French Artillery has attained a marked superiority over that of the place; under its protection the approaches have arrived at about 25 yards from the place before the Town, the ground permitting the sap to be proceeded with; it is doubtless possible to get near enough to the ditch to blow in the counter-scarp with a mine, but it must be considered on the one hand the approaches could not be made without great loss, on the other that it will require at least 8 or 10 days fire, which our Artillery could not sustain without exhausting its supply.

"Before the Little Redan we are 25 yards from the ditch, but are stopped there by the nature of the ground, which is so rocky that it is nearly impossible to advance.

"The moment to give the assault has then arrived, and these are the dispositions which it appears ought to be adopted to give the greatest possible assurance of success to the decisive operations.

"The principal attack should be directed on the work of the Malakoff; if we succeed in scaling it and making a solid lodgment, the fall of the Karabilnia suburb will be inevitable.

"The Russians are constructing a *2nd enceinte* between the Malakoff and the Little Redan; this *enceinte*, partly armed but still incomplete, can be easily scaled in many points.

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"We suppose that the attack in front of the Malakoff will be made by three columns; the first, sallying from the trenches nearest the town, will attack directly the Malakoff work; the second, leaving the trenches nearest the Little Redan, will scale that work, and will then turn the *2nd enceinte;* the third, that of the centre, will leave the 6th parallel, and arriving necessarily a little after the others, will march directly upon the curtain, and after scaling it, will bear to the left to attack the Malakoff, or previously the *2nd enceinte,* if the column on the right shall not have already turned it.

"The object of the three columns will be to scale the Malakoff and the Little Redan and the triangle enclosed between the two *enceintes,* and to maintain the ground against all attempts of the enemy to re-take it. Such is the importance of the position that[1] *the enemy will no doubt make every effort to regain it. It is necessary therefore to preserve that separation of the enemy's forces which results from the great extent of the fortifications of Sebastopol; to this end, when the success on the attack on the Malakoff shall be certain,* and at an agreed signal, the English will assault the Redan, and the French at the same time the works of the town.

"The assault of the Redan will be in three columns; that on the right will pass by the slope to the left of the ravine by Karabilnia; that of the centre marching towards the salient; that of the left by the right slope of the great ravine; in each case the attack of the flank columns will remain dependent on the effect produced by the English Artillery on the Redan Batteries which flank the slopes.

"To avoid the obstacles which the enemy has accumulated at the salient of the Bastion du Mât, the Bastion will not be directly attacked; the principal assault will be on the central Bastion between its salient and the lunette on its left. The column of assault on arriving at the terreplein of the Bastion will extend towards the left to guard against the return of the enemy, who will come doubtless from the side of the quarantine; and when it shall be established in the position, it will turn a part of its force to the right to turn the Bastion du Mât by the gorge, and scale the Garden Batteries. Such are the general dispositions which appear best calculated for every attack in the advanced state of the works, and in the[2] disposition of the forces; but it must be remarked that in the English attack on the Redan, and above all in the attacks of the French on the town, the Artillery which has for a long time kept up only a moderate fire is far from having produced its full effect; the undersigned think that the fire of the Batteries should be resumed with warmth for three days; after this delay, which will bring us to the moment when the supply of ammunition in the Batteries in front of the Malakoff will be nearly exhausted, we shall find ourselves at the most favorable junction for giving the assault. It is important then that the day of attack should be fixed without delay. In fine, the undersigned are unanimously of opinion that any delay in the attack will only diminish the chances of success, and they propose to the Generals-in-Chief to give orders for resuming the

[1] The Italics are not in the original.

[2] There is something wrong in this sentence in the rough translation I have before me.

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cannonade with great vigour for three days, at the expiration of which the place should be assaulted on the three points indicated by day, but at an hour to be decided on."

As before stated, the recommendations made above were accepted by the Generals Commanding; the cannonade took place, and orders for the assault given. The English were however ordered to assault the Redan in one column at the salient "on the given signal" that the Malakoff was in the hand of the French: the signal being the display of the French flag on the parapet. This was displayed in five minutes after the column issued from the trenches, little resistance being made to the unexpected attack given at 12 noon, and when it is said the old guard of the Russians had marched out to make room for the new; it not being desirable to have the old and new guard in the confined space in the Malakoff at the same time during the *feu d'enfers*. It is supposed that this fact was known to Pellisier, and that it was "the secret he would not tell even to his pillow, by which he intended to take Sebastopol," of which we heard some weeks before the day of assault.

The gallant force which composed the column destined for the Redan was separated from that work by 200 yards; it was exposed to a flanking fire from the Garden Battery, 1600 yards distant (which could not have been reduced, even if the five heavy guns mentioned by Colonel Smythe had been mounted) as well as to the fire of the work itself. Notwithstanding the before-mentioned departure from the course experience had taught concerning assaults, but with the expressed object of preventing the Russians from massing their troops to recover the Malakoff, the column entered the Redan, and held it for a considerable time; had it been an enclosed work (as was the Malakoff) they would have been in all probability able to retain possession of it; but this would not at all have affected the foreseen final result.

It will be noticed that of the four columns pushed forward by the French, only one succeeded in retaining possession of the Russian Works; but all aided, as did the single English column, in gaining the desired end—the permanent retention of the commanding site of the Malakoff leading to the immediate evacuation of the Southern side of Sebastopol.

The French soldiers attacking the Little Redan and Curtain fought with their accustomed gallantry; they were mowed down; but they were unsuccessful in obtaining possession of the triangle enclosed between the Little Redan, Malakoff, and Lines joining them.

An incident connected with this assault calls for a repetition of the remark of the French General who witnessed the Light Cavalry Charge:—"*C'est magnifique mais ce n'est pas la guerre.*" A Troop of Horse Artillery came down through the French Trenches, partly prepared for its passage, and into action in the open within 50 yards of the Russian parapets, and was there destroyed.

I close these remarks with the reiterated statement that the so-called Siege of Sebastopol was the attack on a superior Army in a carefully prepared position, which could not be invested and which was abundantly supplied with all munitions *de guerre*, by an inferior Army under divided command; and that this attack should not properly be termed a Siege.

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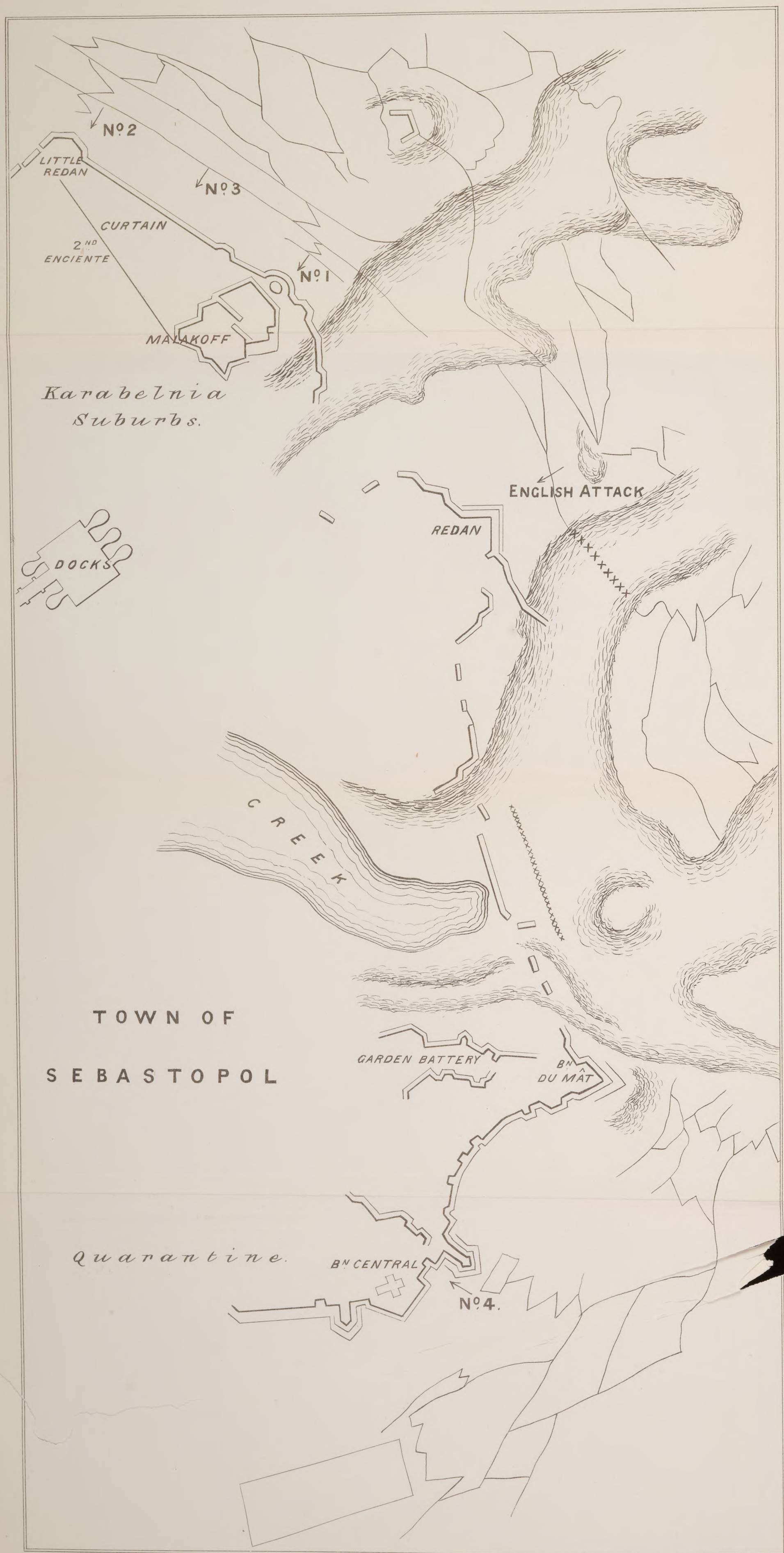

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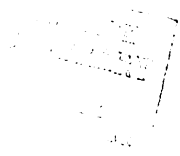

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ON THE MOTION OF A PROJECTILE.

BY

CAPT. P. A MACMAHON, R.A.

In Vol. XI. of the Proceedings of this Institution, Mr. Greenhill has solved the problem of the Motion of a Projectile in a Medium resisting as the cube of the velocity. Taking as origin the point where the velocity is infinite, he finds for the abscissa of the point in the trajectory where the tangent makes an angle $\tan^{-1}p$ with the horizon—

$$x = \frac{w^2}{g}\int_p^a \frac{dp}{(3a + a^3 - 3p - p^3)^{\frac{1}{2}}} \quad \ldots \quad \ldots \quad (1)$$

in which a is the value of p at the origin.

The object of this paper is to show that

$$x_1,\ x_2,\ x_3 \qquad p_1,\ p_2,\ p_3$$

being corresponding values

then $$x_1 + x_2 + x_3 = 0$$

provided that a certain relation subsists between

$$p_1,\ p_2 \text{ and } p_3$$

and to find the relation.

Some new properties of the curve of flight will then easily follow.

Putting

$$3a + a^3 - 3p - p^3 = P$$

and employing the substitution

$$P = (a - p)^3 z^3$$

as in Mr. Greenhill's paper

we have

$$\frac{gx}{w^2} = \sqrt{\left(\frac{3}{4 + 4a^2}\right)}\int_z^\infty \frac{dz}{\sqrt{(z^3 - b^3)}}$$

where $$b^3 = \frac{4 + a^2}{4 + 4a^2};$$

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and consequently

$$\frac{g}{w^2}(x_1 + x_2 + x_3) = \sqrt{\left(\frac{3}{4+4a^2}\right)}\left\{\int_{z_1}^{\infty}\frac{dz_1}{\sqrt{(z_1^3 - b^3)}} + \int_{z_2}^{\infty}\frac{dz_2}{\sqrt{(z_2^3 - b^3)}} + \int_{z_3}^{\infty}\frac{dz_3}{\sqrt{(z_3^3 - b^3)}}\right\} \quad \ldots \quad (2)$$

It is to be shewn that

$$\int_{z_1}^{\infty}\frac{dz_1}{\sqrt{(z_1^3 - b^3)}} + \int_{z_2}^{\infty}\frac{dz_2}{\sqrt{(z_2^3 - b^3)}} + \int_{z_3}^{\infty}\frac{dz_3}{\sqrt{(z_3^3 - b^3)}} = 0$$

provided that a certain integral relation subsists between z_1, z_2 and z_3.

For consider the differential equation

$$\frac{dz_1}{\sqrt{(z_1^3 - b^3)}} + \frac{dz_2}{\sqrt{(z_2^3 - b^3)}} = 0 \quad \ldots \quad \ldots \quad (3)$$

Euler's method of integration gives at once

$$\left\{\frac{\sqrt{(z_1^3 - b^3)} \pm \sqrt{(z_2^3 - b^3)}}{z_1 - z_2}\right\}^2 = C + z_1 + z_2$$

where C is the arbitrary constant.

Rationalising we find—

$$\{-b^3 - \tfrac{1}{2}(z_1 - z_2)^2 C + \tfrac{1}{2} z_1 z_2 (z_1 + z_2)\}^2 = (z_1^3 - b^3)(z_2^3 - b^3)$$

$$\therefore \tfrac{1}{4}(z_1 - z_2)^4 C^2 + C(z_1 - z_2)\{b^3 - \tfrac{1}{2} z_1 z_2 (z_1 + z_2)\}$$

$$+ b^3 (z_1 + z_2)(z_1 - z_2)^2 + \tfrac{1}{4} z_1^2 z_2^2 (z_1 - z_2)^2 = 0.$$

Rejecting the factor $(z_1 - z_2)^2$ we find

$$(z_1 - z_2)^2 C^2 + 4b^3 C - 2z_1 z_2 C (z_1 + z_2) + 4b^3 (z_1 + z_2) + z_1^2 z_2^2 = 0;$$

or

$$z_2^2 C^2 + C^2 z_1^2 + z_1^2 z_2^2 = 2(z_1 z_2 C - 2b^3)(z_1 + z_2 + C)$$

which is symmetrical in z_1, z_2 and C.

Considering, now, C as a variable and putting it equal to z_3, we see that the integral relation

$$z_2^2 z_3^2 + z_3^2 z_1^2 + z_1^2 z_2^2 = 2(z_1 z_2 z_3 - 2b^3)(z_1 + z_2 + z_3)$$

must lead to the differential equation

$$\frac{dz_1}{\sqrt{(z_1^3 - b^3)}} + \frac{dz_2}{\sqrt{(z_2^3 - b^3)}} + \frac{dz_3}{\sqrt{(z_3^3 - b^3)}} = 0$$

whence integrating between limits

$$\int_{z_1}^{\infty}\frac{dz_1}{\sqrt{(z_1^3 - b^3)}} + \int_{z_2}^{\infty}\frac{dz_2}{\sqrt{(z_2^3 - b^3)}} + \int_{z_3}^{\infty}\frac{dz_3}{\sqrt{(z_3^3 - b^3)}} = 0$$

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The relation

$$x_1 + x_2 + x_3 = 0$$

is therefore consequent upon the equation

$$z_2^2 z_3^2 + z_3^2 z_1^2 + z_1^2 z_2^2 = 2\,(z_1 z_2 z_3 - 2b^3)\,(z_1 + z_2 + z_3)$$

where

$$z_1 = \frac{P_1^{\frac{1}{3}}}{a - p_1}$$

$$z_2 = \frac{P_2^{\frac{1}{3}}}{a - p_2}$$

$$z_3 = \frac{P_3^{\frac{1}{3}}}{a - p_3}$$

To make this equation rational in $p_1\ p_2\ p_3$, observe that, from symmetry, Euler's integral may be written in either of the forms

$$z_1 + z_2 + z_3 = \left\{\frac{\sqrt{(z_1^3 - b^3)} \pm \sqrt{(z_2^3 - b^3)}}{z_1 - z_2}\right\}^2$$

$$z_1 + z_2 + z_3 = \left\{\frac{\sqrt{(z_2^3 - b^3)} \pm \sqrt{(z_3^3 - b^3)}}{z_2 - z_3}\right\}^2$$

$$z_1 + z_2 + z_3 = \left\{\frac{\sqrt{(z_3^3 - b^3)} \pm \sqrt{(z_1^3 - b^3)}}{z_3 - z_1}\right\}^2$$

To determine the ambiguity of sign, we note that putting

$$z_1 = b + b\sqrt{3}\,\frac{1 + \operatorname{cn} x_1}{1 - \operatorname{cn} x_1}$$

$$z_2 = b + b\sqrt{3}\,\frac{1 + \operatorname{cn} x_2}{1 - \operatorname{cn} x_2}$$

$$z_3 = b + b\sqrt{3}\,\frac{1 + \operatorname{cn} x_3}{1 - \operatorname{cn} x_3}$$

it follows that

$$x_1 + x_2 + x_3 = 0$$

the modulus of the elliptic functions being sin 15°.

Therefore when

$z_1 = z_2$, z_3 is finite;
$z_2 = z_3$, z_1 is finite;
$z_3 = z_1$, z_2 is finite.

So that the lower sign must be taken in each case.

Therefore

$$(z_1 + z_2 + z_3)\,(z_1 - z_2)^2 = \{\sqrt{(z_1^3 - b^3)} - \sqrt{(z_2^3 - b^3)}\}^2$$

$$(z_1 + z_2 + z_3)\,(z_2 - z_3)^2 = \{\sqrt{(z_2^3 - b^3)} - \sqrt{(z_3^3 - b^3)}\}^2$$

$$(z_1 + z_2 + z_3)\,(z_3 - z_1)^2 = \{\sqrt{(z_3^3 - b^3)} - \sqrt{(z_1^3 - b^3)}\}^2$$

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whence adding and reducing

$$z_1^3 + z_2^3 + z_3^3 - 3z_1 z_2 z_3 = z_1^3 + z_2^3 + z_3^3 - 3b^3$$
$$- \surd(z_2^3 - b^3)\surd(z_3^3 - b^3) - \surd(z_3^3 - b^3)\surd(z_1^3 - b^3) - \surd(z_1^3 - b^3)\surd(z_2^3 - b^3)$$

or $$3z_1 z_2 z_3 = 3b^3 + \surd(z_2^3 - b^3)\surd(z_3^3 - b^3) + \surd(z_3^3 - b^3)\surd(z_1^3 - b^3) + \surd(z_1^3 - b^3)\surd(z_2^3 - b^3)$$

an equation which when both sides are cubed will be rational is p_1, p_2 and p_3.

For we easily find

$$\surd(z^3 - b^3) = \frac{\surd 3}{2} \cdot \frac{a(a+p)+2}{\surd 1 + a^2(a-p)}$$

and therefore cubing

$$27 \frac{P_1}{(a-p_1)^3} \cdot \frac{P_2}{(a-p_2)^3} \cdot \frac{P^3}{(a-p_3)^3} = \left[\tfrac{3}{4}\frac{4+a^2}{1+a^2} + \tfrac{3}{4}\frac{\{a(a+p_2)+2\}\{a(a+p_3)+2\}}{(1+a^2)(a-p^2)(a-p_3)}\right.$$
$$\left. + \tfrac{3}{4}\frac{\{a(a+p_3)+2\}\{a(a+p_1)+2}{(1+a^2)(a-p_3)(a-p_1)} + \tfrac{3}{4}\frac{\{a(a+p_1)+2\}\{a(a+p_2)+2\}}{(1+a^2)(a-p_1)(a-p^2)}\right]^3$$

or $$64 P_1 P_2 P_3 = \frac{1}{(1+a^2)^3}\left[(4+a^2)(a-p_1)(a-p_2)(a-p_3)\right.$$
$$+ (a^2 + ap_2 + 2)(a^2 + ap_3 + 2)(a - p_1) + (a^2 + ap_3 + 2)(a^2 + ap_1 + 2)(a - p_2)$$
$$\left. + (a^2 + ap_1 + 2)(a^2 + ap_2 + 2)(a - p_3)\right]^3$$

$$= \frac{1}{(1+a^2)^3}\left[(4+a^2)\{a^3 - a^2(p_1+p_2+p_3) + a(p_2p_3 + p_3p_1 + p_1p_2) - p_1p_2p_3\}\right.$$
$$\left. + 3a(2+a^2)^2 + (a^4-4)(p_1+p_2+p_3) - (a^3+4a)(p_2p_3+p_3p_1+p_1p_2) - 3a^2p_1p_2p_3\right]^3$$

$$= \frac{1}{(1+a^2)^3}\left[4(3a+a^3)(1+a^2) - .4.(1+a^2)(p_1+p_2+p_3) - 4(1+a^2)p_1p_2p_3\right]^3$$

Therefore

$$P_1 P_2 P_3 = \{3a + a^3 - (p_1 + p_2 + p_3) - p_1p_2p_3\}^3 \quad \ldots \quad \ldots \quad (4)$$

which is therefore the relation between $p_1 p_2$ and p_3 when

$$x_1 + x_2 + x_3 = 0.$$

If then, as before, x_1, x_2, x_3 be the corresponding arguments of the elliptic functions, we have

$$x_1 + x_2 + x_3 = 0,$$

since $$x_1 = \frac{(4+a^2)^{\frac{1}{2}}(4+4a^2)^{\frac{1}{2}}}{3^{\frac{1}{2}}} \frac{gx_1}{w^2},$$

w being the terminal velocity.

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In particular

when $$p_3 = a \qquad x_3 = 0,$$
$$x_1 + x_2 = 0,$$

and equation (4) becomes

$$2a + a^3 - p_1 - p_2 - a\,p_1 p_2 = 0,$$

or $$p_1 = \frac{2a + a^3 - p_2}{1 + a p_2}.$$

Therefore when

$$p_2 = 0 \qquad \text{(at the vertex)},$$
$$p_1 = 2a + a^3,$$
and $$x_1 = -x_2;$$

that is :—at the point whose horizontal distance from the origin is the same as that of the vertex, but in the opposite direction, $p = 2a + a^3$;

$$p_2 = \infty, \quad p_1 = -\frac{1}{a}, \qquad x_1 = a;$$

$$p_2 = \frac{1}{a}, \quad p_1 = a^4 + 2a^3 - 1;$$

$$p_2 = -a, \quad p_1 = \frac{3a + a^3}{1 - a^2};$$

$$p_2 = 2a, \quad p_1 = \frac{a^3}{1 + 2a^2};$$

$$p_2 = 3a, \quad p_1 = \frac{a^3 - a}{1 + 3a^2};$$

$$p_2 = ma, \quad p_1 = \frac{a^3 + (2 - m)\,a}{1 + m a^2};$$

giving corresponding values of the angles of inclination of the tangent at points equidistant from the origin.

Again, since when $x = 4K - 2a$, $p = \dfrac{2a^3 + 3a}{a^4 + 3a^2 + 3}$;

therefore, when $x = 2a - 4K$,

$$p = \frac{2a + a^3 - \dfrac{2a^3 + 3a}{a^4 + 3a^2 + 3}}{1 + a\,\dfrac{2a^3 + 3a}{a^4 + 3a^2 + 3}}$$
$$= \frac{a\,(a^6 + 5a^4 + 7a^2 + 3)}{3\,(a^2 + 1)^2}$$
$$= \frac{1}{3}\,(a^3 + 3a).$$

And since $x = 2a$, when $p = \frac{1}{3}\,(2a^3 + 3a)$

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therefore when $\mathrm{x} = -2\mathrm{a}$

$$p = \frac{2a + a^3 - \frac{2}{3}a^3 - a}{1 + a\left(\frac{2}{3}a^3 + a\right)}$$

$$= \frac{a^3 + 3a}{2a^4 + 3a^2 + 3}.$$

And since when $\mathrm{x} = 2K, \quad p = -a - \frac{2}{a}$,

therefore, when $\mathrm{x} = -2K$,

$$p = \frac{2a + a^3 + a + \frac{2}{a}}{1 - a^2 - 2}$$

$$= -a^2 - 2.$$

When $p_3 = \infty$, equation (4) becomes

$$(3a + a^3 - 3p_1 - p_1{}^3)\,(3a + a^3 - 3p_2 - p_2{}^3) = (1 + p_1 p_2)^3$$

and then $\mathrm{x}_1 + \mathrm{x}_2 = \mathrm{a}$ or $\mathrm{a} - 4K$

and putting in succession

$$\mathrm{x}_2 = \pm\frac{4}{3}K, \quad \pm 2K, \quad \pm 2\mathrm{a}, \quad \pm(4K - 2\mathrm{a}) \quad \&\mathrm{c.},$$

the expression of p in terms of a for various other values of the argument, will depend upon the solution of a cubic equation.

Various other relations may be deduced from equation (4), both generally and for particular values of the argument (a).

Thus $\mathrm{a} = 2K \qquad a = 0$

$$\mathrm{a} = \frac{4}{3}K \qquad a = \infty$$

These properties are important in tracing the curve.

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NOTES

ON THE

EMBARKATION AND DEBARKATION OF HORSES,

AND THEIR

CARE ON BOARD SHIP.

BY

LIEUT. H. HEYWOOD CLARK, R.A.

Embarking and Disembarking.

In embarking horses, if they have to be lifted in, there is no doubt that to sling them in ordinary slings is quicker than to pull them up in boxes. Horses sometimes cause a great deal of trouble and loss of time when being got into these boxes, and with ordinary care slings are just as safe. But it is better still (if possible) to walk the horses on board by means of a long gangway.

On board each transport there should be several long gangways, as it may occasionally happen that none are at hand on shore when wanted. As a rule the horse after being led on board by means of one of these gangways, is lowered into the horse stalls down the hatchway by slinging, or in boxes; but it would take less time and trouble if they were led down gangways into their stalls also. This of course necessitates the hatchways being sufficiently big to admit of the gangways being placed down them (*vide* Fig. 1). By this means, having gangways from the ship to the shore both fore and aft, and gangways down both the forward and after hatchways, the horses would be led in two continuous streams down into their stalls.

Horses can be led into their stalls from shore by means of gangways, at the rate of over 100 an hour, or nearly 2 per minute. Thus with two gangways, one fore and one aft, the horses of a Battery would be embarked in three quarters of an hour (a Battery, war strength, has some 150 horses). The same applies, of course, to disembarking. In disembarking horses from a transport into horse boats, slings must be used to lower them, as there is not room to lower boxes into the horse boats when nearly filled with horses. Coir mats must then be hung over the side of the vessel to prevent the horses bruising themselves; care also should be taken that there are no projections or air scoups left out against which the horse might swing and hurt himself on being lowered. Also metal rowlocks or iron stanchions should not be allowed to remain in the horse boats. The sides of these horse boats should be as plain and smooth as possible, so that there should be nothing to damage the horses on being lowered into them. I have seen a horse have his hind quarters cut right open with a gash some 8 inches long, from his having been lowered close to one of these iron stanchions

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or rowlock projections. Beginning to struggle before he was safely landed in the bottom of the boat, he staked himself. This horse came home with the Battery without having been well enough to do a day's work, the wound was so long healing. The rowlocks should be cut in the sides of the horse boats, and not be iron fixings, as when it is getting dark, it becomes difficult to see where the horse is being exactly lowered.

General Remarks.

For horses going to hot climates a height of 8 feet between decks is a minimum. Ventilation must be ample; down every hatchway there should be plenty of windsails led under towards those horses which have not the benefit of being near the hatchways.

The men on board a transport should be in quarters quite distinct from those in which the horses are, otherwise the men's messes are filled day and night with the unwholesome smells caused by the horses, and in hot climates the heat in the men's messes is made unbearable by this addition of foul air. The following is a description of the situation of the men's quarters on board a hired transport vessel:—

On the main deck, on either side of the machinery were ranged the different messes, so that on passing out at either end the soldier found himself at once among the horses; nor were there doors or partitions to shut off the men's quarters from the horses. Accordingly, what with the heat of the engine works (added to the heat of the climate), the closeness caused by the proximity of the horses and their smell, and the narrowness of these mess compartments, caused by their being on each side of the machinery, the men's quarters were almost unbearable to remain in, and there was no way of letting windsails down into them.

It is most desirable therefore to arrange that the men be located quite apart from the horses. It is possible for the men to avoid all this of course, except during meals, by merely remaining on deck. There is nothing like fresh air to revive the horse, too, who is exhausted by the heat or whose lungs are affected. There should therefore be plenty of spare stalls on deck into which any horse that is suffering from inflammation of the lungs, &c., can be removed.

With regard to keeping the men's quarters *apart* from the horses,—the horses might all be put aft on the main deck and the deck again below that; and the men forward on the main deck, with the harness, &c. on the deck below them. The men would thus be perfectly apart from the horses, and, being forward, no horse smell could reach their messes. Or all the horses might be put on the main deck both fore and aft, and the men on the deck below that again, either fore or after. The horse smell rises, so that being below the men would suffer no inconvenience on that score. This latter is the best way of the two perhaps, as the horses all equally get the benefit of the fresher air of the main deck, and there is less climbing up and down ladders for the stablemen, as the horses are all on the same deck. Also if a passage runs right the whole length of the ship, it is easier to get about, and less gangway ladders are necessary, which are a source of frequent blocks and delays when many have to be perpetually running up and down them.

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General Management.

Horses should be stalled by pairs as they go in harness, or those that are accustomed to go next each other; they do not then bite or interfere with one another. To begin with, the horse is put on short diet, and does best on bran, the quantity of oats gradually increasing and taking the place of bran. The horses heads should be tied rather to the upper bolts than the lower (*vide* Fig. 7), and short; this gives them support in rough weather. There should be plenty of windsails or other means of ventilation. There is nothing like vinegar to refresh a horse; he should have his face and nostrils sponged with it at least once a day. Disinfectants should be used every day liberally, and put under the platforms of the stalls after they have been cleaned out. There should be plenty of spare stalls, about 1 to every 9 or 10. In rough weather the men should, as far as possible, stand to their horses heads, as this gives them more confidence. In rough weather the slings should be sufficiently loose, whereas in calm weather they should be tightened to let the horses rest themselves. Now and then the slings may be rolled up and the horses properly groomed: this refreshes them. Hand-rubbing the legs should be done once a day, at mid-day stables. In rough weather cinders or mats should be put under the horses feet, but cinders are not very effectual. Hay shortly becomes worse than useless. Coir mats are I think best; but they should not be put under a horse's *hind* feet, as they there get clogged with dung and give trouble in cleaning again.

The urine should run free down channels of such a gradient as would take it away at once, care being taken that the drain holes for the urine do not get clogged up with dung, &c., and so cause the urine to stand stagnant; fine wire or other grating round the drain holes would be useful to prevent this. The immediate draining of the urine leaves the stalls dry, which is of great importance to the health of the horse and also allows of the dung being brushed up dry.

Stable Duties.

Morning stables.—Clean out stalls; sweep up the passage behind the horses; sprinkle disinfectants; water the horses; sponge out eyes and nostrils; feed with hay; afterwards with bran and oats. *Mid-day stables.*—Pick out feet; sweep up passage; clean up stalls; fill tins with water for watering. *Officers call.*—Water the horses; then groom; hand-rub legs; sponge face and nostrils with vinegar; then feed with bran and oats. After dinner change stalls; lift up platforms and clean out; sprinkle disinfectants; stablemen then feed with hay for an hour. *Evening stables.*—Clean out stalls; sweep up; sponge nostrils, &c., water and feed as usual; stablemen feed with remainder of day's hay.

Average daily rations of horse:—

Hay	10 lbs.
Oats	5 lbs.
Bran	5 lbs.
Water	8 galls.
Nitre	½ oz. in feed.

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For the first few days the proportion of bran to oats should be about 4 to 1, or 7lbs. of bran and 2 of oats, as the horse gets sooner reconciled to his novel position when not fed up to working condition. The oats are then increased and the bran diminished towards the close of the voyage, till the proportion stands about 4 to 1, or 8 lbs. of oats and 2 of bran.

Stalls.

The average inside measurement of stalls for English horses is, with breast-pad fitted (breast-pad measures say, 9 ins. thick), 6 ft. long and 2 ft. 3 ins. wide (or without breast-pad near 7 ft.). Now a horse's "length" is said to be 8 ft.; deducting 2 ft. for his head and neck, his actual body length from his haunches to his breast is about 6 ft. Consequently there are only (with the pad in) a few inches to spare between the horse and the haunch and breast pieces of the stall. When the ship begins to roll, the horse tries to swing his body correspondingly, but without altering the position of his feet. But not having room to lean forwards and backwards at will, from the shortness of his stall, he is *obliged* to shift his feet forwards and backwards each roll the ship makes (*vide* Figs. 2, 3, and 4). He cannot continue to do this perpetually with each roll of the ship; and the result is he either falls on his knees or his haunches. Of course the sling ought to prevent his falling down and enable him to regain his feet, but it does not always do this; for the horse may either (*vide* Figs. 3 and 4) slip back on his haunches leaving his fore feet in the sling or the reverse; or (as sometimes occurs) something connected with the sling may break from the continual strains and jerks it receives, and the horse is then powerless to prevent his feet slipping up sooner or later.

The effect of taking away the breast pad was tried, so as to lengthen the actual room in the stall, and give the horse more space. It was eminently successful, and with the exception of the bruising his breast received from the bare wood, the horse received no other injuries thereafter. Allow play of about a foot both front and rear of a horse, and he will, when accustomed to his new position, keep his feet with the greatest ease. The reason is that he never now shifts the position of his feet, but merely leans backwards and forwards according as the ship rolls (*vide* Figs. 7, 8, and 9). Room must be calculated, then, for the greatest roll a ship is likely to make. A foot both front and rear is sufficient I think for all cases, and if the horse is inconvenienced by having too much room for a slight roll, it can easily be lessened by putting in more pads, which should be supplied on board in plenty. This would bring the length of a stall from breast-piece to haunch-piece to 8 ft. 9 ins., or 9 ft. say: *i.e.*, the ordinary inside measurement of 6 ft.; increased by a foot in front and in rear to allow the horse to sway; and 9 ins. for the pad. With a stall of this length a horse can sway himself naturally with each roll of the ship; this is the chief and most important consideration of all, for it enables the horse to outlive a storm which might otherwise kill him. If he once gets down on to the floor of the stall among his neighbours' feet, there is no knowing where the mischief will stop.

With a view to enable the urine to drain off quickly and without

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Calculation of length of hatchway for gangway

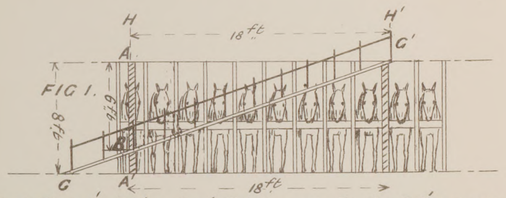
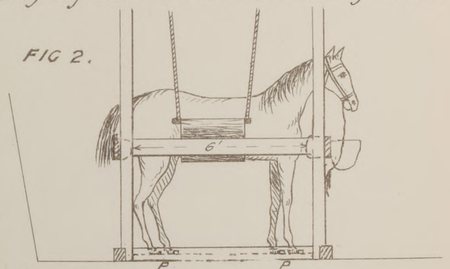


FIG 1.

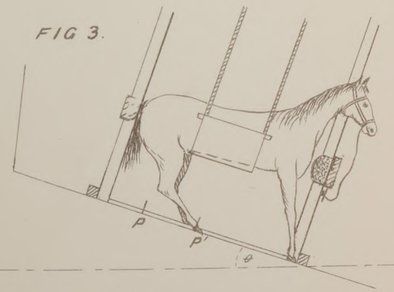
A.B = 6 ft A.A' = 8 ft or height tween decks G.G' = gangway.
H-H' is the hatchway. = 18 ft long, better still 24 ft,
The gangway has then a still easier gradient.

FIG 2.



denotes Haunch piece.
- - - " — Breast piece.
- - - " — Pad for Breast.

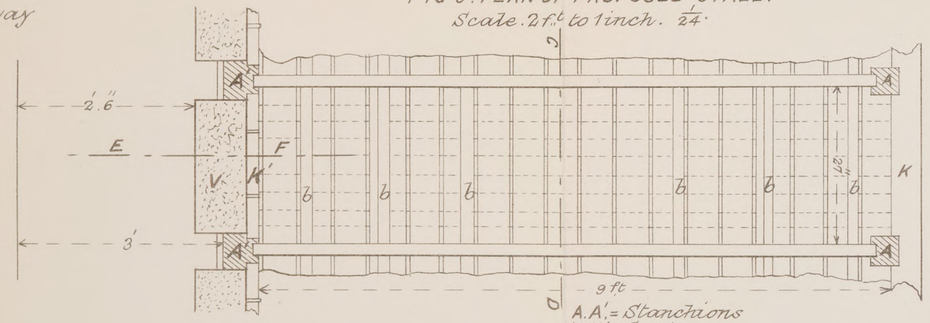
FIG 3.



SCALE, FOR FIGS 2.3.4.7.8.9. ONLY.

INS. 12 6 0 1 2 3 4 5 6 7 8 9 10 11 12 FEET.

FIG 5. PLAN OF PROPOSED STALL.
Scale. 2 ft. to 1 inch. 1/24.



A.A'. = Stanchions
K.K'. = Cants.
V. = Dung pan.
b.b. = Battens for foothold for horse.

Section of platform at C.D.

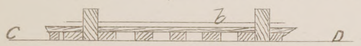
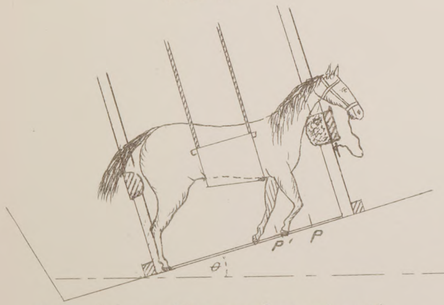
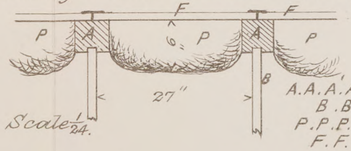


FIG 4.



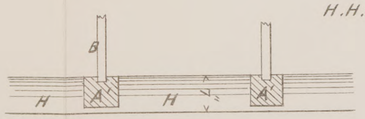
P, Position of horses feet at rest.
P' " " " " shifted to suit roll of ship.

Plan showing Breast & Haunch arrangement.



Scale 1/24.

A.A.A.A'. = Stanchions.
B.B. = Bales.
P.P.P. = Breast pads.
F.F. = Moveable breast pieces.
H.H. = Strong wood haunch piece.



Cross section through Dung pan at E.F.
Scale 1/10.

b = Batten.
V = Pan.
K' = Rear cant.

Plan & section of iron fixing for rear Stanchions.
Scale 1/10.

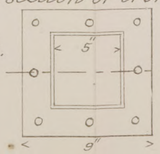
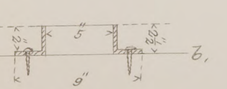


FIG 6.



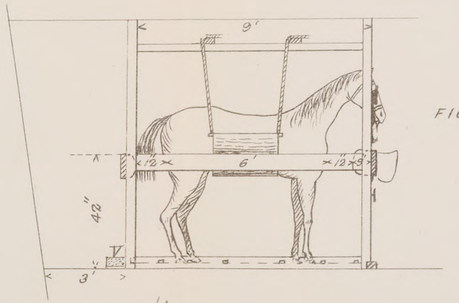


FIG 7.

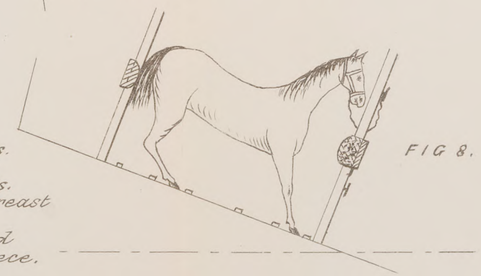


FIG 8.

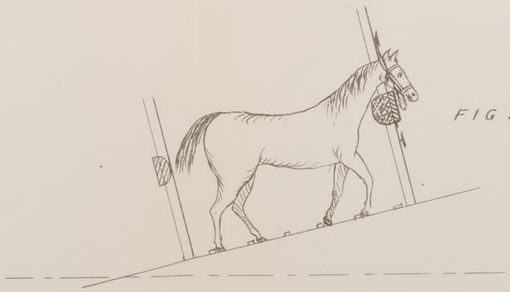


FIG 9.

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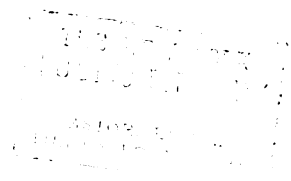

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getting clogged, there should be some arrangement whereby the dung may be collected separately and so cleaned up in the dry state, which will lighten, too, the work of the stablemen. The means I suggest is roughly as follows:—The platform is raised above the deck an inch or so to enable the urine to run away free, and leave the platform always dry for the horse to stand on, it is of the following description:—There are 5 longitudinals, 9 ft. long 3 ins. wide and 1½ in depth, with intervals of 3 ins. between each = 15 + 12 = 27 ins., which is the width of stall; across the top of these are transverse pieces on which the horse stands; they are 18 in number, each 5 ins. wide and 27 ins. long, with an inch interval between each, gives 90 + 18 = 108 ins. = 9 ft. length of stall (*vide* Fig. 5). In rear of the platform are the stanchions (A′), similar to those in front (A). In front and rear are "cants" K K′; K being in front of (A) stanchions and being the means of keeping them fixed; whereas (K′) is dovetailed into stanchions (A′) about 1 inch about the deck for drainage, and being merely a limit to the platform for the horses feet; but stanchions (A′) are fixed by means of rectangular iron fixings bolted to the deck, into which the heels of the stanchions are fitted (*vide* Fig. 6). The "cant" or rear piece (K′) should be stout red pine about 4 ins. high by 2 ins. thick, standing 1-in. in parts at least above the deck for drainage, this gives total height above deck of 5 ins. Upon this rear cant is hung between each stanchion a tin pan or tray, perforated with plenty of fine holes to drain the urine, being 24 ins. long (the distance between the stanchions) by 9 ins. broad and 4 ins. high, being 1-in. clear of the deck. The stanchions (A A′) are 5 ins. × 5 ins., and the rear stanchions (A′) should be 3 ft. from the side of the ship. The drain holes at the end of the 3 ft. passage should be plenty large and surrounded by wire grating to catch any dung or other clogging substance, which should be at once cleared away. There should be plenty of battens on each platform for the horse to gain foothold from, at least two for his fore feet and two for his hind feet, distributed somehow as in plan (*vide* Fig. 5). The remainder of the stall is not affected in any way by these above-mentioned alterations. Though it is improbable that the horse will stale into the pan (V), unless he is standing well back in the stall, yet it will enable the groom or stableman to sweep up the dung immediately, and put it into the pan, there to drain dry until it is full, when it can be lifted off and emptied, thus saving the man several journeys backwards and forwards, and at the same time leaving the urine to run away free by itself. One great argument for the lengthening of the present pattern of stall is that, for smaller horses, they can always be shortened by the addition of pads, which should be plentiful in store on board ship; whereas if a stall is found short, nothing can be done to lengthen it if necessary.

The idea of giving the horse more room to sway in, is derived from actual experience *in a storm*; for it was found that on the removal of the breast pad, the horse was better able to keep his footing. It is wonderful how soon the horse gets into the swing of the ship, swaying himself each time in the opposite direction as well as, or better than a human being. Provided he be not forced each time to shift his feet, but can freely sway to and fro, he will keep on his legs in the worst of storms.

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A TIME FUZE FOR FIELD ARTILLERY,

BY

LIEUT.-COLONEL J. B. RICHARDSON, R.A.

In Vol. XII., No. 2, of the R.A.I. Proceedings, Major G. B. Macdonell has brought to notice an ingenious fuze with the intention of supplying a want very greatly felt by all practical Field Artillerymen. A fuze which may be regulated to a fraction of a second, and which admits of rapid setting and re-setting would more than treble the power of our guns when firing shrapnel.

When firing at a dummy enemy, as commonly practised in India, it is remarkable how little damage is done; while a careful record of the hits made will show that by far the greater part of even this small effect is due to the action of perhaps two or three well-burst shell out of some eighteen rounds fired, the greater number of shell having either small or no effect. Much ammunition is wasted, inasmuch as a great majority of the shrapnel fired do not do a sixth part of the mischief they are capable of doing under favourable conditions. This is particularly noticeable where the dummies are protected, however slightly, by cover, such as shelter-trenches, gun-pits, or inequalities of the ground, when, unless shells are burst under the most favourable circumstances, they do no harm.

Many causes come into operation to produce this—to the battery firing—disheartening result, but over these the officers and men have no control. A wrong estimate or finding of distance, bad laying, incorrect judgment of the result of previous shell, bad boring of the fuze, uncertain ramming home, bad choice of platform, and consequent difference in level of wheels, and bad service of the gun generally, the Battery may greatly obviate by better training; but for a weak shooting, comparatively powerless gun, for difference in strength of the powder in the cartridges, and for the inequality in time of flight of its time fuzes, it has to depend on others. I believe that to the irregularity in burning and want of perfect means of adjustment of

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time-fuzes the indifferent results obtained in ordinary shrapnel practice may mainly be attributed, though many are content to throw the lion's share of blame on the feeble powers of the 9-pr., with which the Field Artillery in India is exclusively provided. If one shrapnel shell thrown by the gun is found to do great execution, the probability is that if it was made possible to burst other shell at an exactly similar point these others would also do great damage, and that, though the 9-pr. is weak, if it could be so used as to invariably utilize the full power of its shrapnel, it would still be a formidable weapon.

No two wooden time fuzes, bored at the same hole with the rough means at present at the disposal of batteries, appear to burst a shell at the same period, and when to this defect is added the impossibility of taking into account fractions of a second, during which the shell in its flight passes over many yards of ground, it is evident that conditions exist under which no training or skill will enable gunners to burst a second shrapnel shell so as closely to imitate the good results of a former round.

Major Macdonell's fuze would probably supply the great want we feel of a fuze which can be set to a fraction of a second, and, when set, altered at pleasure, and which, being also a concussion fuze, prevents a shell being altogether thrown away should it chance to strike close to the mark before the time arrangement has acted; but it in nowise obviates the radical defect common to all service time fuzes, viz., the uneven burning of all composition.

That there is a great difference in the burning of individual fuzes is fairly recognized in our manuals, where we read—"The time of burning of a fuze increases with its age. Fuzes that have been long stored sometimes burn irregularly, giving premature and blind shells;" and again—"The time of burning increases as the barometric pressure diminishes." It would seem that the time has arrived when it may be fairly asked, "Can any fuze depending for the accuracy of its action on the length of time during which a given column of composition burns be regarded as satisfactory?" Think of the conditions our fuzes are subjected to—climate, age, continual severe jarring, extremes of barometrical pressure when used, &c.—and the question will generally be answered in the negative. Great pains have been taken to ensure uniformity in the column of composition, whether straight, spiral, or circular, but, under such conditions, it is not surprising that the action of time fuzes based on a principle so little under control as the effect of fire on a combustible should prove unsatisfactory, and it is as well to attempt to turn in search of some other agent more under control. It is in the hope of suggesting a new departure that I point to a mechanical power always present during the flight of a rifled shell, capable of very exact measurement, and which, so far as I know, has not been utilised or recognised as an agent by which a fuze might be exploded at any required moment of the flight of a shell, but which may possibly, and apparently easily, be turned to advantage. I allude to the rapid and regular rotation of the shell itself, and I cannot discover any inherent difficulty in utilising a very little of the work done by the shell in rotating (which is at present in excess of what is

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required to keep the axis of the shell steady during a flight to extreme shrapnel range), so that it may be made to explode a concussion fuze at any given revolution of the shell, and consequently at any point of its flight, no matter at what height above the sea level the Battery may be in action, or how old the fuze in the shell may be.

To do this the fuze, which should be a concussion fuze, would probably require to be transferred from the head to the base of the shrapnel shell, in itself an advantage, while the revolutions of the shell might be recorded by the aid of a disc moving as freely as possible on a central pivot, and provided with a flange or flanges, probably of very small dimensions, which on the shell leaving the gun would extend beyond its circumference. A moderate expenditure of ingenuity in the adaptation of existing means would ensure such an action, that the composition of the concussion fuze would be exploded at the required period, and open the shell by igniting the bursting charge, while this period would be capable of being set beforehand by the Artilleryman.

I merely suggest one plan by which the rotation of the shell could be mechanically recorded: other and better ways will probably occur to men with a turn for mechanics, or may be found by practice. Many objections and difficulties may crop up, but there are none, I think, which could not be surmounted with a very small portion of the ingenuity which has been expended in producing our present very inefficient time fuze. The sudden burst of improvements in Artillery 25 years ago found us in possession of a composition time fuze, and inventors have devoted their talents more to improve the form and construction of composition fuzes, than to looking wide a-field for another system, though success in a matter so exceedingly touchy as the regular action of fire under varying conditions of temperature, pressure, climate, &c., must at all times have been doubtful.

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THE PRACTICE REGULATIONS

OF SOME

EUROPEAN ARTILLERIES.

BY

CAPT. R. A. MONTGOMERY, R.A.

COMMON and shrapnel shell are the chief projectiles in all countries. A small number of case shot are always carried. Austria carries, in addition, some incendiary shells, and uses small charges for high-angle fire, as well as the ordinary full charge. The proportion of common to shrapnel shell is :—

Austria	...	20	common shells to	7	shrapnel.		
England	...	1	"	"	3·5	"	(9-pr.)
"	...	1	"	"	3	"	(16-pr.)[1]
France	...	2	"	"	1	"	
Germany	...	4	"	"	3	"	
Italy...	...	6	"	"	5	"	

Artillery fire may be divided into fine shooting and rough shooting. The first aims at getting the range with the greatest accuracy possible, and is necessary for battering purposes. The second aims at so far determining the range as to ensure that the estimated distance should only differ from the actual distance by less than one-half the base of the cone of dispersion; therefore, that the object fired at is included in the space covered by the unavoidable dispersion of the projectiles. This is the method of shooting most suitable for Field Artillery.

There are, speaking generally, two methods of determining the range :—

1. Shooting gradually up to it.
2. The zone system.

All nations, with the exception of the English, use the zone system, which was first tried by the Germans. In the first, the estimated distance is gradually increased or diminished by small increments of

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[1] The 13-pr. Batteries in Egypt had 1 common shell to 3·6 shrapnel. The 16-pr. Batteries had 1 common shell to 3 shrapnel. Each Battery had also 800 incendiary stars for use in common shell. These figures give the proportion for each Battery, including the reserve with the Ordnance Department.

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(say) 100 yards at a time, according as the first shot falls under or over, until a shot is seen to fall close to the object.

The English Regulations say: "Set the yard scale to the estimated or measured range, increase or reduce elevation 100 yards at a time according as the shot falls under or over, till a shot falls over or under. Then reduce or increase the last elevation by 50 yards and fire a few rounds. If necessary, make another correction of 25 yards. If half the rounds fall short, the mean point of impact is at the foot of the target."

In the 2nd method—the zone system—large corrections are made at once, so as to determine as soon as possible two ranges between which the object must lie; then by halving the differences the depth of the zone is gradually reduced.

England, France, and Italy use range-finders to measure the range before opening fire. Austria, Germany, and Russia estimate the range by eye, if it cannot be taken from a map.

The Russians have no scale of yards on their tangent scale, but it is divided in lines, each line representing a difference of 50 yards at medium distances. In trial-shot firing the increase or decrease of elevation is carried out as follows:—

At short ranges	a difference of	2	lines or	100	yards is made.
At medium "	"	4	"	200	"
At long "	"	7–15	"	350–750	"

The Austrians have their distance-scale in paces, but, at the same time, the radius of sighting is just a mètre long, and the tangent-scale is divided into millimètres as well as paces, thus complicating the rules for elevation and deflection. The first trial shots are made to enclose a zone 100 to 400 paces in depth according to the range.

All the countries using this method reduce the zone covered by the trial shots to a depth of 50 mètres before group firing is begun, except in France, where it is reduced to 25 mètres.

Austria, England, Germany, Italy, and Russia do not use the elevating-screw for correcting the elevation. In France, on first coming into position, the range is given and the scale made use of; after that changes in elevation are made by the Commander, saying, "With elevating-screw a quarter, half, or whole turn longer or shorter," as may be wanted. In the "*carnet de Poche*," carried by all French Officers, are tables showing the differences of elevation and range due to each half of a turn of the elevating-screw from a half up to four turns. It is only on first coming into action that the range and the elevation to be used are given.

In Germany, alterations are only made by means of the scale of mètres on the tangent-scale.

Austria and Russia lay stress on always opening fire at a range rather shorter than that estimated, as it is considered important that the first shot should be short.

Some regulations give instructions for trial-shot firing in special cases. These might sometimes help to get the range quicker, but would often cause delay in so doing, and at any rate they complicate

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the rules that have to be remembered. As an instance, the Austrians lay down that if the first shot falls very short of the target, the next should be given such an elevation as would probably make it fall near the mark; should it then fall beyond, the range is to be reduced 100 paces at a time till a shot falls in front of it.

In Germany, the regulations do not prevent a Battery Commander altering his range by more than 200 mètres at a time, even at medium ranges, if it is found by the first trial-shot, that he had made a considerable error in estimating the range. To correct the range, only 100 yards at a time is simply following the old method of shooting gradually up to the range, which is now acknowledged to be waste of time, except by the English regulations. To halve the difference of the ranges tried is much the simplest method, although sometimes it may cost a shot or two more.

The real differences begin only when the trial-shot firing is finished. The Germans at once distribute their fire over the object: *i.e.*, each part of the Battery has a certain portion of the object to fire at. Most of the other Artilleries appear to distribute their fire only when that of the enemy is silenced; it is so in Austria and France, while in England and Russia nothing is said about it.

The German regulations, even in firing at living objects, lay more stress on direct hits than on bursting the shells a short way in front of the mark; they try, therefore, to get the mean trajectory to pass through the centre of the object. All other Artilleries seem rather to aim at bursting the shells short of the object: *i.e.*, they try to get the mean trajectory to fall at the foot of the target or a few paces short of it.

This difference in practice is seen below:—

English satisfied if	$\frac{1}{2}$			the number of rounds are short.	
French	" from $\frac{1}{2}$	to	$\frac{3}{4}$	"	"
Austrians	" " $\frac{1}{3}$	to	$\frac{3}{4}$	"	"
Russians	" " $\frac{2}{3}$	to	$\frac{5}{6}$	"	"
Germans	" " $\frac{1}{4}$	to	$\frac{1}{2}$	"	"

The Germans consider that if not more than half the rounds fall in front of the target, the probability is that the range has been found to within 25 mètres.

The rules as to the number of shots after which corrections should be made vary. The French and Russians leave it to the discretion of the Battery Commander. The English say nothing about it. The Austrians correct after 4 to 6 shots have been fired. The Germans correct after not less than 8 shots.

The French and Russian methods would probably lead to hasty corrections being made, the necessity for which was not yet proved. They also have no rule for correcting the elevation, if several successive shells at the commencement of group-firing fall short of the target. The Germans do this at once if the first three fall short, the Austrians if four do so. The latter have also a rule that if in group-firing three out of the first four shots fall beyond the target, then a correction for 25 mètres should be at once made.

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The Germans only allow a correction to be made if less than a fourth of the shots are short. They have also a rule that if a direct hit is made during the trial-shot firing group-firing should begin at once: the others seem to assume, as a matter of course, that this would be the case.

Trial-shot firing being completed, small corrections have still to be made for each gun according to its shooting qualities. The rules for this are nearly the same in all Artilleries, and it is left to the Subaltern to make, within certain limits, the necessary alterations in elevation or deflection.

The French are an exception, as they have the peculiar rule that a gun shooting steadily either under or over cannot have any change made in its elevation except by order of the Battery Commander. It is doubtful if he would be able to superintend the shooting of each gun of his Battery sufficiently to be able to do this, although he has a N.-C. officer by him to keep a record of the practice made.

In all countries correction for deflection is made by the Subalterns. The Russian, Austrian, and German rules are nearly alike; the deviation must exceed a certain fraction of the range for any alteration to be permissible; if it exceeds this, a correction should be made after the first shot. With the Austrians the limit of error allowed without correction is $\frac{1}{300}$ to $\frac{1}{350}$ of the range, according as it is short, medium, or long. The German limit is $\frac{1}{1000}$ of the range at all distances, which at long ranges makes the permissible error smaller than that allowed by the Austrians, and being the same fraction for all ranges is, therefore, perhaps the better of the two.

The French do not allow deviation within any limits; if there is any, it is at once estimated and a correction made for it. There are very detailed directions for ascertaining the amount of the correction to be made. They are not satisfied with mere estimation, but try to find some means of assisting the eye in judging the deviation. One method is; the gun being laid on the object, the deflection-leaf of the scale is moved until some auxiliary mark which stands out very clearly is seen over it; suppose the leaf to have been moved 9^{mm}, and it is estimated that the shell fell at a distance from the target equal to one-third of that between it and the auxiliary mark; the deflection to be given would then be $\frac{9^{mm}}{3} = 3^{mm}$.

Another method is; after the first shot has been fired, lay the gun on the mark, and then move the leaf till the place, where the shell struck or burst, can be seen over it; the difference on the deflection-scale gives the correction to be made. These rules appear complicated. An easier one to remember could be got from the fact that in the French gun the radius of sighting is 800^{mm} long, and the deflection-bar is graduated in millimètres; therefore the alteration of the bar 1^{mm} would shift the point of impact of the shell $\frac{1}{800}$ of the range.

Such importance is attached by the French to corrections for deviation, that they are trying to get a sight which will not be affected by the wheels not being level. On service, however, the most important cause of error in direction is the difficulty of seeing the object distinctly through the smoke, and not the unevenness of the wheels.

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It has been mentioned that Austria is the only nation that carries in addition to the full charges smaller ones for high-angle fire at concealed objects. These charges are a little over 13·5 and 9·5 ozs. for the heavy and light guns respectively. The rules for practice with high-angle fire are the same as for direct fire, with this exception, that it is considered necessary that from a-half to three-quarters of the projectiles should fall behind the covering mass; therefore the range to the further edge of the zone formed in the trial-shot firing is that taken for the group firing.

Shrapnel.

The Germans, Austrians, and Russians all open fire with common shell to find the range, and, having found it, shrapnel fire is begun with the elevation and length of fuze due for the range to the nearest edge of the zone formed in finding the range. If the fuzes are not burning right, then the position of the point of burst must be regulated. This is done in various ways. The Austrians always maintain the elevation due to the mean trajectory found during the trial-shot practice: if the burst is too low they shorten the length of time-fuze, if too high the fuze is lengthened. They aim at getting a mean point of burst 100 paces (80 mètres) in front of the target, and at a height above plane equal to one-third of the number of hundreds of paces in the range. When it is clearly established that the normal burst is too far over or under the mark, they allow the elevation as well as the length of fuze to be altered.

In 1871, when the Germans first introduced shrapnel shell they used the same method as the Austrians. A few years afterwards they changed, and combined changing the elevation with changing the length of fuze. This was found to be complicated and unsatisfactory, so they have now gone back to the old method (as appears in the practice regulations issued a short time ago), and alter the length of fuze while keeping the elevation due to the range found. The length of fuze is increased or decreased so as to get the mean point of burst as near as possible at the best distance (50 mètres) from the mark.

Changing the length of fuze is advocated if the range has not been quite accurately found with common shell, or when the first few shrapnel fired seem to have no effect. In such a case, the length of the fuze is increased gradually so as to shift the point of burst 50 to 100 mètres at a time, till all the bursts are seen to be behind the mark, it is then gradually shortened until all the bursts are again in front of the mark. If the mark fired at is behind cover, hidden by smoke or otherwise difficult to observe, this method of moving the point of burst backwards or forwards is of use, as it ensures a great depth of ground being swept by bullets.

In Russia, the rules as to shrapnel fire are very complicated. Neither the fuze nor the tangent-scale have a scale of distances, the former is graduated in tenths of a second, the latter in lines as mentioned above. The range is found with common shell, then the scale must be altered to suit the trajectory of the shrapnel and the fuze set; for these adjustments a range-table is absolutely necessary. The further cor-

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rections, *i.e.*, regulating the point of burst, are made by simultaneous changes in the tangent-scale and in the length of the time-fuze, for which this rule has to be remembered: at a range of less than 15 lines elevation on the tangent-scale, one line on the scale is equivalent to ·3 of a second for the time-fuze, and for longer ranges is equivalent to ·2 of a second. This is a complicated rule to have to use on service.

The French shrapnel fuze is a combined time and percussion fuze. To set it as a time fuze, one of the holes in the brass case must be bored through; if this is not done the fuze is a simple percussion fuze and acts on graze. The range can therefore be found either with common or with shrapnel shell, if with the latter the fuze is not bored.

No regulations for shrapnel fire have yet been issued. The following information is taken from the report of practice carried on by one of the French regiments. The object was first included in a zone as in common shell fire, using the fuze as percussion; the zone was then reduced in depth until it equalled the difference in range due to one-eighth of a turn of the elevating screw. The tangent-scale is then set at the mean of the elevation due to the two ranges thus found, and the fuze is bored ·5 of a second longer than the number of seconds shown on the range-table in the corresponding division to that giving the number of degrees for the tangent-scale.

During the practice they try to make five out of six of the shell burst in the air. Any corrections necessary are made on the fuze alone, approximately according to the following scale:—

If out of 6	shell all burst on graze,	the fuze is shortened	...	·6	of a second.
" 1	bursts in the air,	the fuze is shortened	...	·3	"
" 2	"	"	...	·2	"
" 3	"	"	...	·1	"
" 4	"	"	...	·05	"

If all six shells burst in the air, the mean height at which they burst decides whether the length of fuze should be corrected or not. The height of burst should be:—

4 to	5	mètres at	2000 mètres.
6 to	7·5	"	3000 "
8 to	10	"	4000 "

Distribution of fire commences only when the length of fuze has been fixed as above.

The English regulations say (p. 147, M. of F. A.) that the correct elevation should be found with common shell and percussion fuze, as quicker and requiring less ammunition than when shrapnel shell is used.

When shrapnel fire begins it should be deliberate, two rounds being always fired with the same elevation and fuze before any correction is made.

The corrections necessary are carried out as follows (p. 146, M. of F. A.):—

(*a*). Shells bursting short: increase the length of fuze a graduation at a time, till a shell is observed to burst over,

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then reduce the length of fuze one graduation. Shells bursting over: reduce the length of fuze one graduation at a time till a shell bursts short; go on with this length of fuze.

(*b*). If the shell burst too high to be able to say whether they burst over or under, reduce elevation and proceed as in (*a*).

(*c*). If the shell grazes short of the target before bursting increase the elevation and proceed as in (*a*).

The medial line of cone of dispersion falls below the trajectory of the shell if it had not burst, therefore to get the full effect rather more elevation than that due to the range must be given.

In the exceptional case of finding the range with shrapnel shell, it would be done as follows by almost all Artilleries:—

(1). Regulate the height of burst so that the point of burst can be well observed.

(2). Then enclose the object in a zone of fire, and continue firing with the elevation and fuze due to the range to the nearest edge of this zone.

The Germans in such a case would fire by divisions, and try to form a zone 50 to 100 mètres deep, as with common shell. If a German Battery is in action firing shrapnel, and has to change from its first mark to one that is apparently only a little nearer or a little further off, the method selected for finding the new range would be that of gradually increasing or decreasing the former one 50 or 100 mètres at a time, rather than that of forming a new zone of fire.

The Austrian regulations say nothing as to whether the guns should be fired singly or by divisions; the zone is, however, in all cases to be reduced only to a depth of 100 paces.

In Russia, the height of burst is regulated by altering the tangent-scale. The range is determined to a distance of about 50 mètres.

The Austrians are the only nation that lay down rules for firing at concealed objects. They try to get the range to within a difference of 30 to 80 paces (instead of 100 paces as above), with a moderately high point of burst. The object is to get some value out of the lower half of the cone of dispersion; and to do this, the range having been found with common shell, shrapnel fire is begun with the longer of the two ranges found, and the position of the point of burst so regulated that about one-fourth of the shell will burst behind the covering mass. This would sometimes be very difficult to observe accurately. The length of the fuze is only altered if three shells in succession burst behind the covering mass.

Practice at a Moving Object.

Most practice regulations devote some space to the subject, but its great difficulty is not fully recognized by all. The following rule is laid down by all: the ranges of conspicuous objects, lying in the pro-

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bable line of advance of the enemy, should, if possible, be ascertained beforehand, so that he may be met at once by a rapid and effective fire.

The Austrian and German regulations are very similar, the latter being the more precise of the two. They lay down that when firing with common shell at an object moving towards the Battery, practice should begin with elevation for a range of 200 to 400 yards shorter than that estimated. If the first shot falls over, reduce the range sufficiently to ensure the second one falling short. There is no good to be got by including the object in a zone of fire as in firing at a stationary mark, and this would never occur unless the true range was at first greatly over-estimated. If the first shot falls short, then, if circumstances allow of it, fire may be continued very slowly till the object is seen to enter the zone of ground effectively covered by it. The fire is then continued at this range until two successive shell fall beyond the object. The range is then at once reduced 200 mètres or more. These regulations do not recognize any change from slow to quick fire when the object enters the effective zone for the purpose of covering it with as many effective shell as possible. The reverse of the above is employed if the object is moving away from the Battery. When it is moving at right angles to the line of fire, the guns are laid ahead, or, if the mark is a column, on the head of it. In the case of an object moving diagonally across the front of the Battery, the only remark made is, that it is very difficult to fire with effect, unless it has been possible to get beforehand the range of some point by which the object must pass.

It is stated that shrapnel fire should only be used against objects moving slowly, and under circumstances favourable to observation, and should be carried out as with common shell.

The French regulations, for firing at an object moving at right angles to the line of fire, lay down that the time elapsing between the No. 1 finishing laying the gun, jumping on one side and the actual firing of the gun must be allowed for. The No. 1 remains laying the gun until the order "No. — gun, Fire!" is given. The first shot is always laid short, if possible. Any necessary correction for deflection is at once made by altering the deflection-scale; any change in the elevation is only made on the order "No. — gun, Fire!" by means of the elevating-screw, just as the No. 1 leaves the gun. The tangent-scale is not altered. As when firing at a stationary mark, the object will be enclosed in a zone of fire, and nothing more being said on the subject, it may be inferred that the depth of this zone will be reduced, as in the former case, to 25 mètres, equivalent to one-eighth of a turn of the elevating-screw. If the object approaches the Battery, a slow fire will be carried on at the shorter of the two ranges due to the zone in which the object is included until a shell falls beyond it: then rapid fire will be carried on until several shell in succession are seen to go over; then the elevating-screw is altered so as to reduce the range by 150 to 200 yards. The French never alter the tangent-scale; all corrections for elevation are made with the screw. The practical effect of this rule does not seem to be satisfactory. If all the guns are

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ready when the first shot is fired, the remaining guns carry out at once any correction in elevation ordered by means of the elevating-screw. A correction having been once made, there can be no object in the No. 1 continuing to look over his gun (see above); also there is no means of knowing the exact elevation given to the gun, so as to know what should be given when laying for the next round. If, however, all the guns are not ready when the first shot is fired, the Subaltern must calculate the number of turns of the elevating-screw to be given to his guns after they are laid and before they are fired. Example: when the first shot is fired, the Left Division guns have not been laid. The range is judged to be 1400 mètres, the first shell falls short; No. 2 gun is given another turn of the elevating-screw equal to an increase of 200 mètres in the range, this is also short; No. 3 gets another turn, making the range 1800 mètres, and the shell falls over; No. 4 takes off half a turn, making the range about 1700 mètres, and the shot still falls over; No. 5 must then lay with a quarter of a turn less. If the guns had all been ready, these corrections would have been followed all through; but, as this was not the case, the Subaltern must work a sum in addition and subtraction, with the result that the gun, after being laid with the elevation according to scale for 1400 mètres, is given additional elevation due to $1\frac{3}{4}$ turns with the elevating-screw. This sort of method would never work well on service.

Nothing is laid down as to the depth of zone allowable. If it is to be that due to one-eighth of a turn of the elevating-screw as in firing at a stationary mark, say 25 mètres at a medium range, it will be found impracticable on service. The rules for firing at an object moving away from the Battery are the reverse of these.

The Russian rules for firing common shell at an object moving away from or towards the Battery are very similar to those of the Germans. They enclose the object in a zone about 200 mètres in depth, and then fire slowly at the shorter or longer range, as the case may be, until the object comes well under fire; they then fire the guns that are loaded independently or in a salvo. When the object passes out of fire, the range is reduced or increased by from 100 to 400 yards, and the above process repeated.

The rules for shrapnel fire are rather more complicated. If the object is advancing, a zone of 100 to 200 mètres in depth is formed with shrapnel, then one division fires slowly with an elevation for 50 mètres more than the shorter range found. When the burst of the shell is observed to be behind the object, the other guns which are ready loaded fire independently or in salvoes, with the elevation due to the shorter range found in determining the zone as above. The process is then repeated at a range 100 to 200 mètres shorter. If the mark is moving away from the Battery, a range is determined at which the shells appear to burst beyond the mark; a Division then fires slowly, as above, with elevation for a range 50 mètres shorter than that determined, and as soon as a shell is seen to burst short of the object all the other guns fire rapidly.

The rule for firing at an object moving across the front of the Battery is—give deflection enough to allow for the time of flight of

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the shell, and the pace at which the object is moving, then fire the gun as the object crosses the line of sight.

The English regulations say: "If possible, find beforehand the ranges to conspicuous objects near which the enemy is likely to pass, so as to be able to open an effective fire as he passes them. If this cannot be done then if the target is moving towards the Battery, fire slowly with an elevation less than that necessary for the original range to the target till a round is observed to hit or fall over; then fire rapidly half-a-dozen rounds (or a salvo); then reduce the elevation by 200 yards, and proceed as before. If the target is moving away from the Battery, begin as before, only with more elevation than necessary until there is a round short or a hit; then rapid fire; then increase the range by 200 yards. If the target is moving across the range, lay on the head of the column or other body of troops with the elevation for the range."

The Germans lay down that every position must be reconnoitred by the Commander, who precedes the Battery for this purpose. In selecting a position, efficacy of fire, then cover are to be considered. How the reconnaissance is made, and how the Battery advances to take it up, is left to its Commander. The Austrian rules are similar. With the Russians a Staff Officer leads each Battery forward, and where there are two Captains with a Battery, the junior accompanies the Staff Officer during the reconnaissance of the position, the senior brings up the battery.

The French regulations are very full on this subject. The Battery Commander, accompanied by two trumpeters and three N.-C. officers, rides forward to examine the position. Having reached it, the three N.-C. officers dismount, two take the ranges with Boulenge's Telemeter, the third goes along the front of the position, to make sure that all the guns can be laid on the object; the trumpeters mark for the flanks of the Battery. The three N.-C. officers return to the Battery with orders as to the road by which it is to move up, also as to the pace and formation to be observed. The regulations state that this method will only be practicable when taking up the first position, and not for changes of position under fire.

The English regulations say that, in selecting a position, care must be taken to have an uninterrupted view of the object when the guns are in action; the guns should, if possible, be on level, sound ground, and advantage be taken of any cover available.

The German Commander always remains mounted, the French one dismounts, while the Battery is in action. The other countries say nothing on this head.

Field-glasses are used everywhere. The French have also a telescope on a stand, which is put up as soon as the Battery comes into action. The Germans have one also, but use it seldom.

The different sorts of fire are distinguished as follows by nearly all nations:—

"Flank fire.," *i.e*, each gun being fired in turn from one flank to another of the Battery.

"Salvo firing," *i.e.*, all being fired together.

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The different rates of firing are:—

"Slow fire:" each gun is fired by order of the Commander.

"Ordinary fire:" each gun is fired in turn.

"Quick or independent fire:" each gun is fired independently.

For the latter fire, with common shell or shrapnel, the Germans use "flank fire," and with case they fire by divisions, or each gun independently.

The Austrian "quick fire" is always carried out by each gun independently. The French use it and call it "*feu à volonté*." The Russians for "quick fire" use only "flank fire," or "fire by divisions." They do not fire each gun independently, even for case. Their name for "slow fire" is "fire by command."

All nations, except the Germans, lay down that trial-shot firing is to be carried out by "slow fire." The Germans leave it to the discretion of the Commander. The French and Germans are the only nations that state anything as to the rate of fire expected. The former, say two to three shots a minute, the latter three to four. These rates show what is expected from the skill and discipline of the gunners.

The Germans say each gun should fire once every minute and a-half, or two minutes, the time between each gun being fired varying from 15 to 20 seconds. In France it varies from 20 to 30 seconds. If every shot is to be noted the German rate cannot be much quickened, and, this being so, it would appear that the Austrian and Russian 8-gun Batteries do not gain in rapidity of fire over 6-gun Batteries, and therefore have on this point no advantage. In Germany the Subalterns repeat only the order as to the range. With the other nations all commands are repeated by them, and in France by the Nos. 1 as well. This repetition is necessary in Austria and Russia owing to the great front of the 8-gun Batteries.

The extent of front of Batteries in different countries is as follows:—

Austrian	=	114	yards.
English	=	95	"
French	=	81	"
German	=	81	"
A light Russian	=	114	"
A heavy Russian	=	137	"

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NOTES

ON

PRACTICE IN CORK HARBOUR.

BY

CAPT. R. A. MONTGOMERY, R.A.

DURING the summer of 1882, the Garrison Batteries stationed in Cork Harbour varied the monotony of constantly firing at a stationary target by devoting a few rounds to practice at a target towed by a steam launch.

A short account of the practice and the result obtained may be of interest to the Officers of the Regiment.

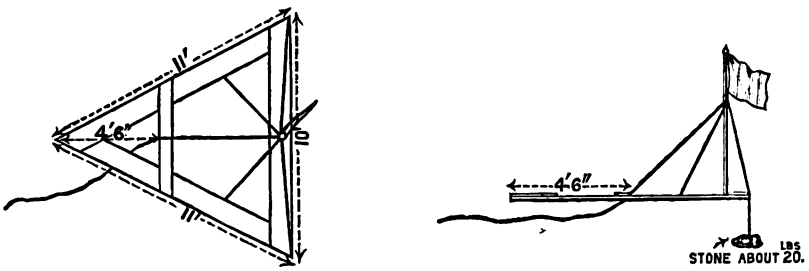
The N.-C. officers and men of the Batteries took great interest in the results obtained.

It was thought that the shooting of the Batteries would be improved, and its practical value at the same time tested, if some portion of the ammunition allowed for the annual practice of each Battery were devoted to practice at a moving target.

With this object Major-General Godby, then the C. R. A. of the Cork District, made arrangements to carry out this kind of practice in Cork Harbour. The amount of ammunition to be allotted for it was determined as follows :—

The number of rounds required for the competition practice of each Battery was deducted from its annual allowance, and one-fourth of the remainder was reserved for practice at the moving target. Only those men were allowed to fire at the moving target who had proved themselves to be really good shots at the stationary target.

By the courtesy of the Senior Commissariat Officer, Cork District, the use of a steam launch was obtained to tow the target. The nature of the target used will be easily understood from the two drawings



Scale 4' to 1"

above, which are taken from sketches kindly made for this Paper by Lieut. F. Bushe, R.A., the Adjutant of the R.A. in Cork Harbour.

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Deal planks of scantling, 1½-inch by 10 inches were used, and it was made by the coxswain of the R.A. boat, the materials being obtained from the Ordnance Department.

The rope was fastened underneath the framework, so that when the strain came the tendency would be to make the nose of the target rise instead of burying itself, which would be the case if the rope were fastened on the upper surface. The stone shown hanging in rear acted as a counterpoise helping to lift the nose of the target.

It was found on trial that even when moving at 8 to 10 knots an hour, the target showed no inclination to tow under. The actual rate during practice was 3 to 4 knots an hour.

The rope used was a coil of 1½ inch tarred rope, a length of 80 to 100 yards being let out during practice. When testing the target, as much as 150 yards was let out without in any way affecting the steadiness of the target.

The practice was carried out between the 5th and 17th of September, under the superintendence of Lieut.-Colonel Ryan, R.A., in command of the R.A. in the harbour.

The Batteries practising were:—

No. 1 Battery, 1st Brigade, South Irish Division (Lt.-Col. Broadrick).
„ 2 „ „ „ (Lt.-Col. Ryan).
„ 3 „ „ „ (Major Ormsby).

The guns used were 64-pr. M.L.R. guns, mounted on standing garrison carriages, at a height of 200 feet above the sea, and 20-pr. B.L.R. guns, 80 feet above the sea.

The projectiles were solid shot for the 20-pr., and common shell, either plugged or with blowing charges, for the 64-pr.

Errors in range are taken from the practice report kept by an Officer on the launch, those in direction from the Battery report.

No. 1 Battery fired on the 5th September, 12 rounds of shot from the 20-pr. R.B.L. Estimated ranges 1200 to 1300 yards. Out of 11 rounds 9 were "over," mean error 49 yards; 2 were "under," mean error 40 yards; 6 rounds were in "line;" 3 averaged 30 feet to the right; 2 averaged 8 feet to the left. With reference to the line of motion of the target all 5 rounds fell in rear of it. One round was 400 yards short, and is omitted as exceptional.

On the 17th of September the Battery fired 5 rounds of common shell with blowing charges and time fuze from the 64-pr. M.L.R. gun. Estimated range, 1200 to 1500 yards. All the shell burst short at a mean distance of 58 yards from the target, mean height above plane 14 feet.

No. 2 Battery on the 5th of September fired 6 rounds of shot from the 20-pr. B.L.R. gun. Ranges by range-finder, 1230 to 1550 yards. The result was, 3 rounds were "over," mean error 35 yards; 2 were under, mean error 40 yards; 2 of these rounds were each 5 feet "left," and fell behind the target with reference to the direction it was moving in; 3 rounds were in "line." The 6th round was 400 yards short, and is treated as exceptional.

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On the 12th of September 14 rounds of 64-pr. common shell, plugged, were fired. Range by range-finder 1200 to 1500 yards. The result was, 3 rounds were "short," mean error 27 yards; 1 was "range;" 10 were "over," mean error 19 yards. 6 rounds were in "line," 1 round was 15 feet to the "right," 7 were to the "left," mean error 7 feet; 6 rounds fell behind the target, 2 in front of it with reference to the direction it moved in.

No. 3 Battery practised on the 11th September, and fired 6 rounds of 64-pr. common shell, 1 with time fuze and blowing charge, 5 were plugged. The ranges by range-finder, 1340 to 1560 yards.

The shell with time fuze acted at 30 yards "over," and 10 feet above plane. Of the remaining 5 rounds, 1 was "target," 2 were "range," one being 6 feet "right," the other 6 feet "left;" 2 rounds were "over," mean error 15 yards, and both in "line."

The same day 6 rounds of solid shot were fired from the 20-pr. B.L.R. gun.[1] Ranges by range-finder, 1350 to 1490 yards. The result was, 1 round was "range," 5 were "over," mean error 23 yards; 3 rounds were "line," 3 were "left," mean error 13 feet.

On Sept. 12th, 9 rounds of solid shot from 20-pr. R.B.L. were fired. Ranges by range-finder, 1350 to 1500 yards. The result was, 1 round was "range;" 3 were "under," mean error 21 yards; 5 were "over," mean error 22 yards. In direction 2 were "line," 3 were "right," mean error 3 feet; 4 were "left," mean error 4 feet.

Watkin's Depression Range-Finder was used during this practice with good results. It had only been issued a short time before the practice took place.

The weather was favorable during the whole of the practice.

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[1] The 20-pr. guns used by this Battery were 200 feet above the sea.

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HINTS TO OFFICERS

TAKING OVER

DRAFTS FOR INDIA FOR THE FIRST TIME,

AND

CONVEYING THEM UP COUNTRY TO THEIR DESTINATION.

BY

CAPTAIN J. C. DALTON, R.A.

Introductory Remarks.

These notes are taken from my own experience in taking a largish draft out to India last Trooping Season. They are intended for the benefit of those who have to perform this unpleasant but necessary duty for the first time. I have entered into some very elementary details: but as it so often falls to the lot of a young Officer, straight from the Academy almost, to take out drafts, I trust they may not be altogether unnecessary.

Without great care an Officer may lose money by his draft; and he should be particularly careful to note the very smallest expenditure and obtain the necessary vouchers for it, for during the time he has the draft many small sums have to be paid by him, and they amount up in an incredibly short time to a sum which it may not be convenient for him to lose.

Agra, N.-W.P., *23 March, 1880.*

As will be seen, these have been delayed for over two years; but in the hope they may be of use I publish them now.—*J. C. D.*

Experiences connected with taking over Drafts for India, and conveying them up Country to their Destinations.

First receipt of Order.

Received Horse Guards' letter at beginning of December to proceed to Leith Fort on 18th December and take over a draft for India, to be embarked at Portsmouth on 23rd inst.

On receipt of this, after acknowledging it, I wrote privately to the Officer Commanding Depôt Battery at Leith informing him that I would arrive there on 18th December, and requesting him to make

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arrangements for a quarter for me in the Fort, and also begging him to select a trustworthy man out of the draft to be my servant, and a N.-C. officer who knew something of office work to act as my clerk, during the voyage.

Officer's Ticket.

I kept my Horse Guards' Order safely, for it is necessary as a voucher to support all claims for travelling expenses, &c., and it may be needed to show at the railway station to get an Officer's ticket. As regards the latter, it is important to find out at the station whether an Officer's ticket is cheaper than an ordinary first class ticket. Government will not allow for the price of an Officer's ticket at twopence per mile if the ordinary first class fare be at a lower rate than that.

Having settled the train that I would take to Edinburgh I wrote again to Leith Fort, stating the hour that I should arrive on the 18th inst., and asked that my servant might meet me at the station. It is not necessary to write to the Commanding Officer and trouble him with small details referring to yourself; for if you know any other Officer there personally, he will arrange all such matters for you.

Arrival at Station where Draft is.

Reporting Arrival, &c.

Having arrived at Edinburgh and found my servant waiting for me, I proceeded to Leith Fort, and found the quarters of an Officer, who was on leave, ready for me. I then left cards at the Mess for the Colonel Commanding and for the Officers; and next morning called on the O. C. the Depôt Battery at his office and reported my arrival officially to him in uniform (the Colonel being on leave).

I then received my orders; which were, that I should embark in a steamer at Granton Pier on the 20th at 3 p.m., land at London at the Irongate Wharf, and march to London Bridge Station, where there would be a special train ready to take us to Portsmouth Dockyard, where we should embark on board H.M.S. "Euphrates." I reported my arrival in Edinburgh to the General Officer Commanding the District, in order to receive any orders he might choose to give me.

Taking over Draft.

In the time I had to spare before embarking there was much to do. Firstly, I had the draft paraded, and made them show kits, noting what few deficiencies there were, which I got made good before starting. Next I went through the men's accounts with the Officer Commanding the Depôt Battery, and saw what credits and debts I had to take over. An Officer taking out drafts should be very careful in taking over the men's money that he gets all the credits paid him in full, and unless the debts are few and very small (up to and under 15s. a-man) they should not be deducted from the credits, but he should take them over as debts. In the case of large debts, the Officer Commanding the Depôt has to settle with the Officer Commanding the Battery to which the man goes on arrival in India. The men must all be settled up with previous to embarkation, and the Officer in charge of the draft must see that they have no complaints or claims outstanding when he takes them over.

"Waiting" men for Draft.

See that there are several "waiting" men ready settled up with to take the place of any who may fail to turn up at the last moment. For

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this reason the final balance-sheet cannot well be made out until the last moment. Arrange for the place and time of parade, taking care to parade a good hour before the time; for, when taking a large draft from the place they have been stationed in, there must always be a great number that will give you much trouble to keep in order. Settle on the clothing, &c., to be worn, so that the men may be dressed alike. The most convenient dress is, for R.H.A., pantaloons and jack-boots, second dress jackets and forage caps; for dismounted men of R.A., patrol jackets, trousers, Wellington boots and forage caps; and for mounted men, R.A., the same, with pantaloons and jack-boots. The Regulation dress is marching order, and it may not be left to the discretion of the Officer of the draft what dress the men wear, still he must always endeavour, as far as he can, to save the men's best things, bearing in mind that not only do their clothes get very much spoilt on board ship, but also that they get mislaid and lost, and often stolen, so that the man who has his clothes safely stowed away in his kit has the best chance of preserving them and of saving his pocket afterwards. Another thing to be remembered is, that as soon you get your men on board the troop-ship they wear their sea-kit clothes regularly, except perhaps on Sundays or other days, when the Officer Commanding Troops on board may require them to parade in their cloth clothes.

Dress for March.

Each man on leaving is supplied with a sea-kit. This contains a suit of serge and a knitted sea-kit cap,—a suit of white, which is intended for the Red Sea, and a white cap cover,—a cholera belt, blacking, soap, needles and thread, &c. This sea-kit is his own property and stopped out of his pay, but nevertheless he is not permitted to dispose of it until given permission to do so. If possible, the accounts of a draft should be so arranged that they have clear accounts before their advance of pay is made them; in which case, a man would embark with a credit according to the number of days for which the advance is made. Generally, a man gets 45 days' pay advanced. For a gunner of Royal Artillery, without a G.-C. badge, this would amount to £2 14s. 4½d. Then 45 days' ship's rations at 2½d. are deducted from that, viz., 9s. 4½d., and also the price of the sea-kit, 19s. 11d. + 3s. for tobacco, the total deductions being £1 12s. 3½d. This will leave the man a balance of £1 2s. 1d., provided he is without debt or credit up to day before embarkation. This cannot however, unfortunately, be the case with every man, and therefore the credits vary considerably.

Sea kit.

Advance of Pay and Stoppages.

The Officers Commanding the Batteries the men come from will furnish you with a No. 1 Report of the draft, signed by them; also with all the men's documents, Regimental and Battery, also with a correct Nominal Roll of the draft in duplicate, one for yourself and the other to be given to the Embarking Officer. It is W.O. Form 720. Also, an English balance-sheet, which should correspond with the men's ledger sheets. It shows the advance of pay, deductions for sea-kit and ship's rations, and the final balance, Cr. or Dr., that you take over for the man.

Documents.

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Arranging the documents.

In taking over the documents, keep all the Regimental together, arranged in the same order as your Nominal Roll: do not sign the receipt for them until you have carefully checked them, and take a Delivery Voucher for yourself, signed by the Officer handing over the documents. In case, afterwards, any are lost or not forthcoming you can prove whether you took them over or not. The same care should be observed with the Battery documents. Have those of each man pinned together and in a particular order, such, for example, as on the top the Register and Attestation Sheet or Sheets, the Medical History Sheet, Ledger Sheet, Defaulter Sheet, Civil Convictions, Marriage Certificates, Return of School Certificates, &c., and Clothing Return at the bottom. The Commanding Officer, of course, is responsible for the correctness of these; but, if you have time, it will save someone a lot of work hereafter if you have a look through them to see that they are made up to date—that the man has signed for clothing, and signed his accounts, &c. Have all the documents arranged so that you can put your hand on them at any time, and always keep them in the same order.

Cash Balance

Last of all, you receive over the balance of the men's credits, and take it in gold, as a good deal of it will have to be handed over in India in English gold, and the remainder you will make money on by the exchange for the benefit of the men concerned.

N.-C.O.'s for Draft.

Having made these arrangements, and having interviewed your N.-C. officers, and appointed one to act as Sergt.-Major of the draft and the other as Office Clerk, you are ready to start. The documents and money must be in a safe place, as you are responsible for them from the time you take them over. Take with you a certain number of blank Defaulter Sheets, Crime Forms, and two or three Travelling Claims: they will be very useful. If, by any chance, you have to make a longish journey, as I had, before going on board the troopship, it is advisable, if you have an agent at Portsmouth, to get the Commanding Officer to make the cheque for the drafts' balance payable to him, to be placed to your credit; and warn him that you will require gold for it on a certain date.

Parading Draft.

The draft paraded—or tried to parade—at the hour I appointed, and their spirits being very high, there was some difficulty in getting them told off. On these occasions make all the use you can of all the N.-C. officers available in barracks, and request the Commanding Officer to allow them to accompany you till the men are fairly put on board ship, or locked up in the trains. If you have far to march, apply for police to keep the road clear; for every ruffian within miles comes, and they throng the thoroughfare; you will have difficulty in keeping your men in the ranks, and occasionally they escape at the last moment.

Precautions on road.

The Colonel Commanding inspects your draft before starting, and generally, after asking if any man has a complaint, speaks a word or two to them, and you march off.

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In my instance the march was a most difficult one, owing to the locality we had to march through, and the day (Saturday); also from the number of people thronging the roads. It is most difficult to impress on the men, and especially on recruits, that they must be silent. You and your Officers and N.-C. officers must be everywhere, and not lose sight of a single irregularity. In my case the men's baggage was conveyed in the wagons of the Battery and brought up the rear; this proved a most valuable help. On nearing the wharf, mark time in front and get the draft together; they are sure to straggle. Have the course cleared as far as the gangway leading on board: get the men into half-sections, and make them march straight on board, pushing them on if necessary, and don't leave the place until you have seen all on. Then post Sergeants at the gangways to allow none of the draft, *on any account whatever*, to leave the boat. You will next have to see the Embarking Officer in the Saloon, who will require some papers to be given him, with which you will have been provided: but if possible have an Officer on deck the whole time, to see that the men don't attempt to jump on shore or get into the rigging or boats, or get liquor given them. Find out as soon as you can where to stow the men's kits, and where they themselves will be accommodated. Warn them all about smoking between decks. Have all the sea kits piled up in a safe place. Don't allow the men to have any of them until you are on board the troopship, otherwise quantities of things will be lost. See that the women and children of your draft are comfortably provided for: you yourself get them moved to the ship in cabs. You will be provided with passes for them authorizing their passage, which you must produce when required.

Marching Draft on board steamboat.

Sea kits not to be opened.

Women and children.

As soon as you are fairly off you have time to see to all minor details, and have baggage, &c., safely stowed away. Be careful that the men are not placed where there is any temptation to steal or break into the ship's cargo, because many of them are half mad with drink, and for drink will do anything while in that state.

In case you get any complaints from the Captain of the ship that things have been broken into or stolen, have a general kit inspection on deck; post sentries (N.-C. officers) to see that nothing is thrown overboard, and you and your Officers must personally inspect and turn out all the kits. In case of any irregularity either on the part of the men or of the ship's people, it must be reported by you to the A.-Q.-M.-General on arrival at Portsmouth.

Proceedings after leaving harbour.

On arrival at the Irongate or other wharf, tell off your baggage party and let them *only* land: and when all the baggage and the women and children are landed then you may disembark the men and fall them in on markers, previously placed by an Officer or N.-C. officer, in a convenient place. Call over the roll and see that all are present or accounted for. The baggage guard must stay with the baggage which they will have placed in carts either provided for you, or which you must impress for the purpose, and it must get off as soon as possible to

Arrival at London.

Baggage.

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March to railway station.

the Railway Station. March your men in sections if possible, and have your Officers and N.-C. officers distributed along the column. In case of a large draft it is most important to have made arrangements to have Sergeants of the Guards sent down to the wharf to assist your scanty number of N.-C. officers and help to get the men into the train and show the way. We had to march through London in the dark, and it was no easy matter. Police may likewise be procured to keep the streets clear; in the crowded thoroughfares you will have to march in half sections.

Getting into train.

On getting to the Station you will have sent on in front to apprise the Station Master that you are coming, and he will have some one to show you the train; march straight into it, not allowing *any* man on *any* account to fall out; lock the carriages and wait until the baggage is reported in, when you will be ready to move off. The Officer Commanding the draft must take a ticket for the draft, showing the warrants or route which shall have been given him, and filling in the exact numbers. Have your men counted before you start, and in case any men are reported absent, leave word for them to be sent on at once if they turn up. If you can possibly avoid it, do not allow any men to get out of the train during the journey. Even good men are so often like children that you cannot trust them out of your sight: they delay and lose the train. The men should all have had some food before disembarking, and therefore ought not to require anything else until they get on board, when there will be food supplied them. Be very careful of their getting drink, &c., on the platforms, especially if they have any money. Watch narrowly any civilians that may be talking to the men at the windows, as they often bring liquor.

Arrival at Dockyard.

On arriving in the Dockyard, as soon as the train stops, get out yourself, and find out any orders relative to the men. You will probably be ordered to fall them all in in two ranks on a suitable place, and the First Lieutenant of the ship will be there and have them told-off in messes and marched straight on board. They are now out of your hands; but you must keep a baggage guard and the officers' servants to look after the baggage. The Officers' servants take their masters' light baggage straight on board to their cabins, and all orders then about the other baggage are issued by the Naval authorities, and you must pay strict attention to them. Warn the men that they are now under "The Naval Discipline Act," and that they must be careful.

Sea kits.

Get your sea-kits distributed to your men as soon as you can. Your Sergeant will have a list of the sea-kits with the men's names corresponding with the numbers on them. As as soon as you can get a moment to spare, go into Portsmouth to get your cheque cashed and

Precautions to be observed with cash.

the money of the draft all in gold. Keep a few pounds for any expenses on board ship, and then have the rest done up in a chamois leather bag, and that again in a very secure paper parcel and sealed over the string. Write outside, "Draft, — Bde., R.A., £——;" stating the exact amount. The Officer Commanding the Troops on

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board will lock it up for you in the iron safe in his cabin. If any of the money is your own you must specify it, as, in case of anything happening to you, it is necessary to know how much was due to the men.

Travelling expenses.

You will also probably have a Travelling Claim. Get it made up while you are moving, and at any spare moment, and the A.-Q.-M.-General (the Embarking Officer) will sign it for you. Take it to the Staff Paymaster, with all the necessary vouchers attached, and he will pay you the money. If he thinks that some of it will be disallowed, the only way in which you can get it from him is to sign a paper authorizing Messrs. Cox & Co. to pay up any disallowance and debit your account with it.

Routine on board Troopship.

There is not much to speak of as regards the routine on board ship, as it is always the same, and strictly laid down in the "Regulations for H.M.'s Indian Troopships."

Have plenty of Nominal Rolls made out, and see that they are all in the same order as your original.

Tobacco.

You will have been provided by the Officer Commanding the Depôt your draft came from with a list of the men requiring tobacco, and probably you will have the money given you to pay for it. Each man gets 2lbs. and pays 3s. for it. If he does not smoke it is not charged to him. The tobacco merchant will come to you before the ship sails, and you will see your box all ready marked with the title of the draft and the number of pounds. You must pay for it and get a receipt, and then he must see it go on board, and you are not allowed to open it until the ship has sailed, because it is bought duty free. It generally consists of sticks a certain length; two and a bit go to the 2lbs., and I served out two sticks to each man who had paid for the tobacco, and kept the balance myself; later on, I made the men draw lots for it, as the pieces would have been so small had it been divided up.

Parades at sea.

As soon as the men are settled down on board you will have parades every morning at about 10 o'clock. Then see that your men are as clean as they can be under the circumstances; and, if the weather is fine, insist on their shaving occasionally—Sunday, for example—they look so disgustingly dirty when not shaved. The hair must be kept short. Make all the men off duty attend parade, and see that they black their boots, brush their clothes, and keep all the buttons on. See the cloaks occasionally. Men are apt to leave them lying about when on "Watch," and they should all be distinctly marked.

The Medical Officer of the day inspects the men every day, and is apt to make unpleasant remarks if they are not clean; and on the other hand, if they are clean you get credit for it. Go round the decks occasionally and see that the men are fairly comfortable.

Kit Inspection at Sea.

Kits are ordered to be inspected once a week. This is almost a farce, because the men have most of their kits in the baggage-room;

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and there is no suitable place to lay them out in. However, you will find out if many things have been stolen, which is often the case with a lot of drafts of different Regiments, who have no respect for the property of others. Leave nothing of your own lying about the ship, or even in your cabin. If you do you will never see it again.

Prisoners

The Officer Commanding the Troops on board sees the prisoners at a regular hour. Strictly speaking, he has little or no power to punish men, but the Captain of the ship generally delegates a certain amount of power to him, and the Officer Commanding Troops generally permits the Officers Commanding drafts to punish a man by stopping his porter for one day. This is not much of a punishment, but still it will often suffice, and prevent you from bothering the Officer Commanding on small matters. You can also make a man parade clean in the afternoon at some particular hour if he was dirty in the morning.

Defaulter sheets, &c.

You must have the Defaulter and Medical History Sheets handy: the former are necessary when the Commanding Officer punishes a man, or when the Captain of ship does so; and all punishments that would entail a Regimental entry must be entered by you carefully in the Defaulter Sheets. If they affect the man's pay, such as taking away a badge, or cells, &c., you must keep careful record of it. Never delay an hour in entering these punishments, &c., for they are easily forgotten, and may cause great trouble afterwards. If a man gets a small punishment, like three days' grog stopped, for some small breach of Naval discipline, it remains with yourself whether you think it necessary to enter it in his Defaulter Sheet or not. The Medical History Sheets are needed if a man is admitted to hospital. Mind and get a receipt for them from the Doctor.

Paying the men.

The *less money* you give the men *the better*. Everything is found them including tobacco. They like to have money to gamble with when they have played away all their tobacco, and also to buy things in the ship's canteen with. I made it a rule to give no money until after we had passed Port Said. I then let each man who had a balance, £1 and upwards, have 2s. or 1s. 6d., or so, and those between £1 and 15s. got 6d., and those who were under 15s. credit got nothing. I often arranged these balances so as to leave the man with a convenient sum, which simplified my work. For example, if his balance was £1 2s. 1d. I gave him 2s. 1d.

Hair cutting

If you have one man much in debt it is a good thing to tell him off as haircutter for the period you have the draft, and at the end of the time when the draft is given over in India stop 1 anna from each man and credit his account with it. This will help him, and you can see that he does his work properly.

Men if they have money on board find number of ways of getting liquor, especially when in port. They get it in through the ports, with the coals, &c., and pass out their kit often in exchange. You have to be very careful in these matters.

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When *any* money is given you must get each man's signature for it; and if you give pay all round it should be done in presence of an Officer. You must advance some to married people, because their wives very often cannot eat the rations they are given, especially if they suffer from sea-sickness. However, to whomsoever any money is paid, from them must a receipt be obtained; and collect all these together, and make out a list showing what each man has had. You may have other things to pay for the men; for example, sometimes men are sent direct from Millbank Prison to join your draft, and you find they have no kit hardly, and may have to buy them boots to land in. If possible, do not take any man without a kit. If you find out that any are going with the draft who are heavily in debt, and whose Commanding Officer has not fitted them out with a kit, telegraph, if necessary, to him, and have the kit sent to meet the man at Portsmouth. The Commanding Officer must recover that debt as best he can from the Officer Commanding the Battery the man goes to.

Receipts necessary in all cases where money is advanced.

No man to embark without a kit.

Before arriving at your destination, find out the exact size of every man's head, for you will be ordered at Bombay to fit the men with helmets, and it will save you a great deal of trouble if you know the size beforehand. As each man fits his helmet, mark it, with a pencil or something, inside with his regimental number before he goes. Each helmet has one puggaree on it, and the others are given after. If you can take charge of them yourself until you get rid of the draft it saves the men from losing them, and keeps them a clean one to join their Battery in.

Size of heads for helmets.

On arriving in Bombay Harbour, the baggage has to be got up from the baggage-room. A baggage guard must be told-off under an intelligent N.-C. officer; and it is advisable to have the same men who were on it before, as they know the appearance of it. The N.-C. officer should have an exact description of it if possible.

Arriving in Bombay.

Before disembarking, be sure and get your last Messing Certificate from the Paymaster of the ship: and you must pay your wine bill in *gold*, for no cheques are taken on board ship. It is a good thing to have a small courier bag to put round your shoulder in which to carry your money, for it is not safe to put it anywhere except on you. The Officer Commanding Troops will issue the orders for disembarkation after seeing the Staff Officer, and he will also order what dress the men are to wear.

Last messing certificate.

Each Officer will see his draft into the tenders, and each man should carry his knapsack or valise; the black-bags can go with the baggage, provided there is nothing in them the men want to get at. On arriving at the Carnac Bundeh, a Staff Officer will see the drafts into the trains; and before starting each man will get some tea and bread. A certain number are allotted to each carriage, and one or two married men told-off for the women and children. See that none of the men stray, but keep them together till put in the train. The nights are very cold and

Disembarking and embarking in train.

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the men will want their coats, and would be glad of any wrap they could have. After the train has started, when it stops at stations the men generally try to exchange their serge clothes with natives either for money or drink. This ought to be stopped, if possible, for they get little or nothing for the clothes compared to the value of them, and would find them most useful afterwards.

Arrival at Deolali.

The train arrives in Deolali very early in the morning before it is light; much confusion generally takes place; the Senior Officer in the train is in command of it, and he orders the drafts to fall in on the platform; the baggage is all left in the trucks, locked up. Perhaps the Barrack Master alone comes down to meet the train, and a few natives with lanterns. You must get your draft fallen in smartly and numbered off from the right. You will then get an idea whether all your men are there or not, if the rear rank is covered off; tell them off in fours and report to Officer Commanding the Troops in train; he gives the word to march off in succession by seniority, and starts off himself with the Barrack Master in front in the dark. Unless the drafts keep *close* together they are sure to be lost in the dark: and it happened to me that the Officer of the draft in front came to me after marching ever so far, and said that there was nothing in front of him, and he did not know where he was going. We at once countermarched, and after countless troubles we hit upon the line and were shown our tents. You are told how many men are allowed to a tent, and tell them off to their different tents. Next morning you see about the baggage. Report yourself at the Commandant's Office at 11 a.m., and write your name in his book—go to Mess, &c. You must appoint some acting N.-C. officers out of the draft to do the duties of Battery Orderlies, Picquets, Baggage Guards, Copying Orders, &c. In the Book of Regulations that are given you, you will find it all laid down what you are to do, and how many acting N.-C. officers you may make in proportion to the strength of your draft. Write an official letter to the Commandant asking for authority to make these N.-C. officers for the time the draft is going up country, and keep that as a voucher for claiming extra duty pay for them. During the time you are at Deolali it is advisable to have a clean parade once a day, so as to see your men, and see that they are clean and respectable: also inspect their kits and note all deficiencies. The Commandant inspects them on arrival, and in his orders makes arrangements for check rolls to be called at certain hours during the day. All prisoners requiring Regimental entry to go before the Commandant. You are now to pay the men in Indian money at a certain rate which is laid down in the books lent you. I gave at the lowest rate authorized, and never varied each day, so that at the end of the time each day's pay was the same and easy to calculate.

Duties at Deolali.

Acting N.-C. O.'s for Draft.

Daily Payments to Draft.

To a Gunner, Driver, or Trumpeter	per diem	2 annas.
Married " "	"	3 "
Corporal or Bombardier	"	4 "
Sergeant	"	8 "

You must advance the married people a little money, as they have to pay the natives for cooking and washing daily.

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To get money to pay the men with, you go to the Paymaster and ask for an advance of any amount you want within reason—the less you can do with the better. For 120 men I took 100 Rupees, this lasted about five days, and then I got another advance of 100 Rupees, which lasted me out exactly. This 200 Rupees the Officer Commanding the draft has to credit to Government on the Pay List when he joins his Battery, and he recovers it from the Officers Commanding the Batteries the men go to. You have a Daily Pay Sheet which you fill in yourself as you give the men their pay; and when you hand over the draft the men sign for all the Indian pay they have drawn.

Advances from the Paymaster.

While at Deolali you have much work: you have to prepare the "Disembarkation Balance Sheet," which shows the amount the man embarked with, either Debt or Credit, and the deductions to be made from that; they consist of 1st,—the number of days that the man has been at sea under the 45 for which an advance of pay was made. Sea pay at the rate of the man's daily pay, less 2½d. for ship's rations, has to be deducted for each day; example,—for a man on 1s. 2½d. a day pay, his sea pay is 1s., and in my case as we were 30 days at sea, 15s. had to be returned for each man receiving 1s. 2½d. pay, and so on. These amounts when added up for the whole draft represents a goodish sum, which has to be paid to the Paymaster, Deolali, in *English money* before you leave Deolali. The second deduction is the cash and other charges during the voyage that the man may have against him. The third deduction is for barrack and ship's damages, which sum is paid up for the draft by you before leaving the ship. If the men have been located in barracks at Portsmouth for some days previous to embarking, they may have a small charge for barrack damages against them. These make up the total deductions, and you then show whether the man is in debt or credit up to date of disembarkation.

Disembarkation Balance Sheet.

Barrack and ship's damages.

This ceases your connection with English money, every expense after disembarking being in Indian money; you pay for the men's washing, and, if necessary, haircutting, and keep an exact account of all you advance or pay for them. You are liable for barrack damages at each station. After leaving *Deolali* you go to *Khandwa, Sohagpore, Jubbulpore* and *Allahabad*, at which place you generally get rid of your draft. You pay them the same pay up to date, get their signatures for all they have had, give over their documents to the Adjutant (except the Ledger Sheets which you keep yourself), and unless you are detailed to go on up country with more drafts, you proceed to your own destination, having provided yourself with a Nominal Roll of the draft, and the Batteries each man has gone to. When arrived there you have to make out—

Preparing Draft documents

1. True copies of the No. 1 Report you brought with you, for the men of each Battery the draft has been posted to.
2. An extract from Disembarkation Balance Sheet showing the amount of Credit or Debt on disembarkation; each column being accurately copied.

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3. An extract from the Daily Pay Sheet of the draft, showing the amount of Indian money you have paid the men coming up country.

4. The Ledger Sheets made up by you to the date of disembarkation.

5. A General Statement showing how much you owe the Officer Commanding the Battery for the men, or how much he owes you—deducting the debts from the credits. You must allow for the men's credit at the current rate of exchange, so as to let them have the benefit of their English money.

However carefully this is done, there must be a certain amount of correspondence afterwards, lasting over some months, about the draft: but by being careful to keep all vouchers and receipts, and never part with *originals*, you ought not to be a serious loser.

Remember that you are not responsible for anything more than the money handed over to you. You must account strictly for that: but if a man has any complaint about his accounts previous to embarkation, or if his No. 1 Report is wrong (as is often the case), by which means he might temporarily be deprived of Good Conduct Pay, you cannot help that; and that bone must be picked between the Commanding Officer of his old and that of his new Battery.

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NOTES

ON

FIELD ARTILLERY.

(THE SUBSTANCE OF LECTURES DELIVERED AT THE R.M.A.)

BY

CAPT. S. C. PRATT, R.A.

General Principles.

THE general principles regarding the employment of Artillery have in no wise been affected by the introduction of modern rifled guns. Its action consists in fire alone, and mainly in fire at distances beyond the effective range of the Infantry rifle. It has firstly to *commence* and carry on a combat at long range, dealing destruction to the personnel and materiel of the enemy at a period before the action of the other Arms is possible: secondly to *maintain the fight*, to reduce to a minimum the effect of the hostile Artillery and Infantry fire, and thus enable the Infantry of its own side to advance, or throw confusion into the ranks of the attacking troops; and thirdly, to co-operate with the other Arms in dealing a final blow at the opposing force, following up its retreat if victorious, or covering the retirement of its own side in case of defeat.

Influence of modern weapons.

The introduction of rifled Artillery and breech-loading fire-arms, with their long range and deadly efficacy, has however caused considerable modifications in the mode of action of Artillery in the field. At long ranges the power of the *gun* has greatly increased, while at the shorter ones the Infantry *rifle* has obtained an unquestionable mastery. In order to obtain the full power of the first it is evident that guns *must come into action sooner and remain in action longer* than formerly; in order to escape from the second they *must move about less than before*. Irrespective of such general considerations, which might be multiplied, it must be realized that the modern fight has much complicated the mutual tactical relation of the three Arms. To act in unison with the extended-order formations of recent times requires something more than the brute force of materiel or the drill of the parade ground. Assuming the main tactical principles of

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employment to hold true, their application has now become far more difficult. Changes in the system of organization and command have become imperative, and new rules of employment have been deduced from the most recent war experiences. The question of detail in tactical management has yet to be thoroughly worked out; but great progress had been made towards the desired end. To account for the existence of many debateable questions it must be remembered that progress in Artillery tactics in time of peace is most difficult. The practice of the range and the theory of the drill ground contrast vividly with the actual experience of war, and from war alone can we deduce sound rules to work by.

Proportion of Artillery.

No more guns should accompany an Army than can be brought into action on the battle-field. Artillery on the march is practically confined to the main roads, and unless these are numerous and the country exceptionally open for the movement of other troops it is impossible to get more than a certain number of guns to the front in time for action. The experience of recent wars lead to the conclusion that from three to four guns per 1,000 men is advisable, the latter being the maximum. The modern tendency appears to be to increase the number of guns up to the extreme limit. The power of the Infantry has been enormously increased by the introduction of the breech-loader, while the action of Cavalry on the battle-field has been reduced to very small proportions. In order to keep relatively powerful with the one and to compensate for the loss of power of the other, it seems necessary to increase the numbers of the Artillery. The necessity for a prolonged initial engagement of Artillery, and the consequent placing of guns in a more forward position on the line of march, facilitates the carrying out of this increment of power. It must be remembered that owing to the great mobility of existing materiel the number of guns brought on the battle-field, especially in the case of small forces, largely exceeds the above proportion, and examples have occurred of as many as 10 guns per 1000 being in effective action. Artillery, moreover, unless actually captured remain throughout a campaign without diminution in the number of guns, while the other Arms are constantly suffering loss.

Units of Artillery.

The Battery of Artillery has long been considered the fighting unit. Three or four Batteries are grouped under the command of a Lieut.-Colonel and attached as *Divisional Artillery* to each Infantry Division. The remainder of the Batteries, about equal in number to the whole of the Divisional Artillery, are termed *Corps Artillery*, and are at the special disposition of the Corps Commander. To the *Corps Artillery* belong all the Horse Artillery Batteries, and from it are detached the Batteries which the Cavalry Divisions or Brigades may require, or those demanded to carry out some special object. The total number of guns in a Corps vary from 90 in the English Service to 104 in the Austrian.

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In view of the large number of guns brought on the modern battle-field, and the consequent necessity for acting in masses so as to regulate the fire in unison, there is a distinct tendency to deprive Battery Commanders of their independence of action and make the *Division* the working unit of the battle-field. Despite the undoubted advantages of this change it is impossible to admit that it holds good for our service. The dispersion of our Batteries appears an inevitable consequence of our military requirements, and to base a tactical system on a purely paper arrangement can only lead into error. In the event of a European war the difficult question of the *command* of a larger unit by Officers without experience will have to be remedied as best it may: and this appears a point to which attention should be directed in our peace manœuvres.

Reserve of Artillery.

The necessity for having a force independent of the Corps and Divisional Artillery is a matter on which opinion is divided. The advocates of what may be called the German school insist that a reserve, even in name, should not be allowed to exist, that in the attack every available gun should be at once brought in action, and that even in the defence it is a doubtful advantage to keep any guns unemployed. The above views have been recognized by all nations so far as to divide what used to be the Reserve Artillery among the *Corps d'Armée* as *Corps Artillery* in lieu of keeping it in one compact mass. It may be fairly questioned, however, if the results of a one-sided campaign justify the abolition of a reserve altogether. "*C'est l'Artillerie de mon Garde qui décide la plupart des batailles parceque, l'ayant toujours sours la main Je puis la porter partout où il est necessaire.*"[1] Granted that as many guns as possible should in modern war come into action at the commencement of an engagement, is this incompatible with keeping a powerful swiftly-moving force well in hand? The preparatory combat by Artillery when acting on *the offensive* is especially needful, but experience teaches us that under ordinary conditions it is impossible to get up all available guns in time, and that even if that were possible the difficulty of finding effective positions for them is great. As the battle proceeds the Artillery positions, either first or second, become clearly defined, the weak points of the enemy are felt, and the advantage of pushing a fresh force into the fight to ensure a decision is obvious. In considering the possibility of obtaining a position for the reserve guns it must be remembered that they could not be thrown into the fight till comparatively late, when it may be assumed that a dislocation of the first Artillery positions would have taken place, and that gaps will be left by the forward movements of the Batteries in first line. In any case the great range of modern weapons allows of a long range fire in second line if a position more to the front is unattainable. If the force of the above reasoning in the offensive battle be admitted, still stronger arguments hold good for the defence; and it would seem

[1] Napoleon.

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advisable to have a small *Army Reserve*, composed of Horse Artillery guns, as possessing the greatest mobility. On the march and before coming into action such a reserve would with advantage remain with the mass of the Cavalry, and, in the event of a Cavalry engagement, give a preponderating effect to the side which possesses it.

The mere fact of having a reserve well in hand does not prevent it being pushed into the fight at the commencement of an action if there is room for it. As the battle progresses the sphere of action becomes more limited, and the reserve guns return again to the hand of the Commander to be again pushed forward towards a vital point.

Type of Gun.

It is generally admitted that two classes of guns are a necessity in the field. The lighter or Horse Artillery gun having great mobility should be able to keep up with Cavalry in special cases: the heavier or Field gun should possess as great destructive power as is consistent with sufficient mobility to manœuvre with the other Arms on the battle-field. At present we possess two types of field guns—the 9 and 13-pr. and 16-pr.—the tactical advantage of which arrangement is in the opinion of some dubious, and it will be probably remedied soon by the introduction of a light and powerful breech-loader. If an extra calibre of additional power be deemed necessary, it would seem advisable to restrict it considerably in numbers and attach the Batteries to the Corps Artillery, from which they could be detached to meet special emergencies. The war of 1870 between the two greatest Military Powers in Europe, fought over country adapted to the movement of large bodies of troops—a war in which Cavalry played an important part, and the special features of Advanced Guard actions, pursuits, and long flanking movements were conspicuous—a campaign, the detail of the Artillery action in which has been narrated with extraordinary minuteness—teaches the lesson that on the battle-field there is no distinct tactics of the two calibres. On the one hand in difficult ground the lighter guns came into action sooner and with less embarrassment, on the other the destructive effect of the heavier calibre when in action was conspicuous. The question of calibre seems to lie within narrow limits. The heaviest field gun should be used that is compatible with ease in occupying at the trot when drawn by six horses its position on the battle-field. The lighter weapon is adapted for special emergencies, referred to later on. The main objection which exists to the Horse Artillery equipment as it at present exists is the large target which the Battery affords to an enemy's fire.

Type of Projectile.

The projectiles used in the field are—

(1.) A *common shell*, with large powder capacity, used with a percussion fuze. Its effect is produced by the penetrative power of the projectile, which explodes on impact, and by the splinters of the shell.

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It is used in all cases where a large bursting charge is effective, such as the attack of entrenchments, block houses and villages, the destruction of palisades, abattis and obstacles of all kinds. It is also effective against troops in masses: and its moral, if not actual, effect against troops in extended order is considerable.

(2.) *Shrapnel shell,* which depends for effect on the dispersion of the bullets it contains and the splinters of the shell. The powder charge is merely sufficient to break up the shell, which is burst well in front of the object aimed at. To produce its full effect the burst takes place in the air by means of a time fuze, but percussion fuzes can also be used with advantage. Shrapnel should be used against troops in the open or whenever an obstacle does not render useless the comparatively small penetrative power of the bullets.

(3.) *Case,* which can only be used at short ranges for self-defence, in villages or defiles, and at night. Its employment is rare and the proportion of rounds carried small.

The theoretical power of shrapnel shell as tried on the practice range falls far short of its actual effect in war. It is curious to note that ever since its introduction, the *next war* was to witness its marvellous effects and to give "Artillery such a destroying power that it will decide the fate of battles," and yet we have but few instances of its powerful application. To obtain an effective shrapnel fire one must know the range correctly, have an accurate time fuze, and have both gun and fuze laid and adjusted with great precision. The progress in technical Artillery has been considerable of recent years, and it might at first sight appear that the looked-for time of effective shrapnel fire had at last arrived. On the other hand the initial velocities and consequent flatness of trajectory have largely increased. Recent guns have attained a velocity of 1,700 f. s., and there is but little doubt that this will be increased as the nature of the propelling force is more fully worked out. The increase of velocity undoubtedly augments the effect of common shell *against troops,* but it renders still more difficult the attainment of accuracy in shrapnel fire. The destructive power of Artillery has without doubt increased, but it appears dubious whether it is yet justifiable to carry an abnormal proportion of shrapnel into the field. It is but fair to the advocates of shrapnel fire to state that the guns and fuzes used by the French in 1870 were very inferior to those of the present day, and that in 1876 the inferior and uncertain powder used by the Turks, and the low initial velocity of the Russian guns has not fairly tested the efficacy of what is, theoretically undoubtedly the most destructive missile of modern times.[1]

[1] There appears good reason to suppose that the Field guns of the future will be steel breech-loaders, firing shells of about 12 and 20 lbs. weight, with a muzzle velocity of from 1700 to 1800 feet a second. The weights behind the teams will be respectively about 35 and 40 cwt. To partially absorb the great recoil, some sort of hydraulic or compressed air-buffer will be attached to the carriage. Increasing the weight and velocity of the projectile will, without doubt, make greater the effect of shrapnel burst on graze. When furnished with a reliable double-action fuze the shrapnel of the future will probably replace common shell in all cases when troops are being fired at.

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Zones of Fire Action.

The guns of an attacking force come into action at the following distances from an enemy's position:—

(1.) From 2,500 to 1,600 yards. At 2,500 yards the fire of Artillery against Artillery first becomes effective, and increases in power up to the lesser range. In this zone the fire of Artillery has alone to be feared, and the main object of attack will be the hostile guns. As good a position as possible should be chosen compatible with securing unity of direction in fire. The Artillery here plays the principal part, and considerable choice of ground is available.

(2.) From 1,600 to 700 yards. The fire of Artillery becomes very destructive, and the unaimed fire of Infantry has considerable effect. When acting in this zone the Artillery must act in conjunction with the Infantry. Advantages of position must be entirely subordinated to the object of aiding the Infantry in its forward movement.

(3.) From 700 yards up to the position. The aimed fire of Infantry render a choice or change of position possible only under exceptional circumstances.

When acting on the defensive the position of the guns is dependent on the ground taken up. As a rule guns can be better protected than in the attack, as the defects of natural cover can be supplemented by artificial means.

Choice of a Position.

A good Artillery position should have a clear open range to the front, the line of guns being as even as possible and perpendicular to the line of fire. A ridge sufficiently high to see over all the ground in front with a slope behind it to give cover to limbers, and marshy ground or a slope in front sufficient to catch the enemy's shells, provided it does not interfere with forward movement, is advantageous. The tops of high hills are not so good as those of medium height, as they are difficult to get up and advance from, and the effect of common shell is diminished. There should be as little cover in front as possible for the enemy to utilize, and the vicinity of woods, houses, trees, or any conspicuous object in rear should be avoided. Stony ground or stone walls in the immediate front is a disadvantage, and the space in rear should be sufficiently open for guns to come into action simultaneously. The presence of natural cover, such as houses, trees, corn fields or hedges, some distance in front, which can be just seen over, seems often an advantage, as it renders it difficult for an enemy to estimate the correct range. An immediate back-ground, such as a wood or village, makes guns very visible, but a distant similar back-ground has the opposite effect. The flanks of Artillery in action are weak points, and care must be taken to protect them as far as possible. If secured by neither troops nor the nature of ground it is advisable to retire the flank Batteries in échelon. A golden rule to observe is that in choosing a position for guns *the efficacy of their fire, with regard to the special task they have to perform, must be the first consideration, and cover the second.*

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Position on the March.

Artillery on the march are placed more in front than they used to be. Of course variations occur, owing to special circumstances, but in the normal order of march the Artillery of the Advanced Guard marches with the main body of it, covered by a small Infantry force. The Divisional Artillery marches near the head of its own Division, covered by an Infantry unit not less than a Battalion. The Corps Artillery generally marches in rear of the leading Division. The Reserve Artillery of the Army would be placed at the head of the Reserve Ammunition Columns, and should not be more than a short day's march in rear of the main body of the Column.

It has been usual to detach for the Advanced Guard a portion of the Artillery of the leading Division. When Horse Artillery Batteries are wanted it will be necessary to draw them from the Corps Artillery.

When it is necessary to shorten the space in column a good deal may be gained by the temporary separation of the guns and wagons, the latter being left to follow up in rear of the combatants immediately engaged.

March Formations.

Batteries march as a rule on the roads in column of route. In exceptional cases two carriages may march abreast. When advancing to come into action, line at full interval is formed and the guns unlimber simultaneously. When obliged to take ground to a flank, column of sections seems one of the best formations. Close column is handy to work with but is dangerous when exposed to Artillery fire. Most foreign nations divide the Battery into two or three parts—an arrangement which seems advantageous. The French "*batterie de combat*" consists of the guns and three ammunition wagons. The remaining three wagons form a second échelon, which takes up a covered position some 500 yards in rear, and supplies the Battery with ammunition when necessary: a third échelon consisting of the remaining wagons and spare carriages keep still further to the rear. It will be necessary in the course of an action for the Artillery to change its position so as to follow up the Infantry movements. Changes of position should be effected at the greatest speed possible, the Batteries advancing by échelons. The Batteries in action while the others are moving should keep up a rapid shrapnel fire on the enemy, who will naturally fire on the Artillery in movement. In retiring the advantages of rapidity of movement have on some occasions to be sacrificed, as a movement to the rear quicker than a walk gives an injurious impression to the other troops.

Coming into Action.

The position which the guns have to take up should have been reconnoitred beforehand by the Major, up to whom the Battery is brought. Guns as a rule come in action at full interval, utilizing natural cover as far as possible, but keeping the line regular. It is

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not advisable to have them at less than half interval. The wagons should be kept under cover, usually in rear of the least exposed flank.

Fire Discipline.

The main reason that the actual destructive effect of Artillery in the field is so far below what it theoretically ought to be is due to defect in fire discipline. The amount of practice-firing in peace time is small, and there is a somewhat natural tendency to neglect this all important point. Dealing merely with principles it should be noted that—

(1.) The range must be accurately estimated, either by a range-finder or a system of trial shots with common shell, or by a combination of the two.

(2.) The object when found should be accurately aimed at. Among practical nations certain men are told off as "pointers," it being undoubted that there is a strong personal element in laying. That there should be a necessity for this, and that guns are laid on the same principles that they were in the beginning of the century, seems difficult to understand.

(3.) In firing against Artillery, lay all the guns of a Battery on a central gun; when against a Column of Infantry, on the centre of its front.

(4.) At long range and when great accuracy is not attainable use common shell, converging the fire of each Battery on one object. In using shrapnel disseminate the fire.

(5.) Avoid firing over the heads of Infantry. If necessary to do so use common shell.

(6.) Three rounds a minute is sufficiently rapid fire for a Battery under ordinary circumstances.

General Tactical Considerations.

In considering the action of Artillery we may assume that fights are either offensive or defensive in character. In the case of "*combats de rencontre*" either one or other phase may have to be assumed, or one has to be changed into another. It will be noticed that the Artillery acts in certain cases as the principal Arm, notably at the commencement of a fight. During this stage attention can be paid to obtaining good positions, scrutinizing the ground, arranging to mass the guns and converge the fire, and above all obtaining unity of command and fire. As the engagement proceeds the Artillery has to neglect, to a certain extent, its own safety and endeavour by every means in its power to aid

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the action of the other Arms. It is scarcely true to say that Artillery drops to the position of an *auxiliary* Arm. In the middle and latter phases of a fight the effect of the guns may be so powerful that they may continue to play a leading part up to the very close of the fight. The action of the Arm may best be understood by following the course of an offensive battle in the case of small forces.

Battery of the Advanced Guard.

The Cavalry of the Advance Guard drives back the hostile Cavalry patrols and finds that the enemy have taken up a position of some kind in front. The first thing to learn is the details as to position, troops, &c., which is the task of the Cavalry. As an enemy's object is to conceal his true position and keep one at a distance he will probably have detached posts or parties of Infantry to his front. These parties have to be driven back by the Infantry of the Advanced Guard, and to aid them in so doing is the duty of the Battery. The object of the Battery is therefore at first to cover the deployment of the Infantry of the Advanced Guard and subsequently to enable it to drive in the enemy's advanced posts. From the circumstances of the case the guns will come into action beyond the first zone of combat and has little to fear from fire of any kind. As the Infantry advance and the main body of the Advance Guard is fully deployed the guns go forward to take up their first fighting position. It is advisable to come into action close to the road by which the advance is made, and not as a rule to proceed nearer than 2,000 yards from the enemy's main position. Whether a Battery can at once advance to its first position, or is obliged to have recourse to a preliminary or reconnoitring one depends mainly on the lie of the ground and the manner in which an enemy is defending his outlying posts. The guns of the Advance Guard are now under Artillery fire; they have helped to rend the veil in front of the hostile position, and now they have by slow accurate fire to try and provoke the enemy to show where his guns are placed. The Battery cannot hope to do much damage, and it, simply from a frontal position, searches the whole presumed line of the enemy with fire.

When an Advanced Guard encounters an enemy who from any cause is weak and not prepared to make a definite stand, the guns may probably have to come into action at short ranges at once, and thus as it were force a passage without delay.

The offensive character of an Advanced Guard action is liable at any moment to be turned into a defensive one by the sudden attack of a superior force. The Battery has then a difficult part to play; as it will probably be attacked by Infantry at short range. The rule should be to hold ground to the last moment, and endeavour by means of shrapnel and case to check the assailant. The Battery may be pressed hard but it ought to get support soon enough to prevent the guns being carried off.

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Another prominent case occurs in following up a retiring enemy. Here the object of the Advanced Guard is to bring him to bay. The guns advance boldly, and fire rapidly on the retiring *Infantry*.

It will be noticed in Advance Guard actions that the guns form the main resisting power, that their action is throughout involved with that of the other Arms, and that to properly carry out his duty the Battery Commander must not only be aware of the characteristics of an Advanced Guard action, but have a thorough knowledge of the mode of action and amount of support to be afforded by the other Arms.

Attack of Divisional Artillery.

While the Advanced Guard is playing its part the guns of the leading Division receive the order to push to the front. Formed up by their Divisional leader in open order, they have to come into action simultaneously, and, with the Artillery of the Advance Guard, keep down the fire of the enemy's guns. The main object of the Artillery Commander should be to get his guns into the *first principal* position from which they can hope to subdue the enemy's Artillery fire. This spot will be situated in the first zone of fire, and as near the limits of it as the nature of the ground will permit. Allowing a fair margin on either side, the position may be assumed to be in an offensive action *one mile* from the line of the enemy's guns. It will be for the decision of the Senior Artillery Officer whether a deployment at this distance can at once be made, or if a *preliminary* position along with the Battery of the Advanced Guard somewhat further back be first necessary. The decision will mainly rest upon the manner in which the Infantry of the Advanced Guard are holding their ground, and to what extent they have driven back the advanced posts of the enemy. The Divisional guns will as a rule come into action in the centre of the proposed attack by Infantry. The Battery of the Advanced Guard, which will from the nature of the previous action be on one flank or other of the Divisional guns, communicates all detail as to range, &c., but it still keeps to its original task of working with the Advanced Guard troops until it receives distinct orders to the contrary from the Artillery Officer in chief command.

Advance to a Second Position.

While the guns in the first Artillery position are silencing the Artillery of the defence, the first line of Infantry attack with its skirmishers, and supports begins to advance slowly, and carries with it the already engaged Infantry of the Advanced Guard, while the reserves of the first Infantry Battalions reach the line of guns. The decision has now been made as to what portion of the enemy's line the main Infantry attack will be delivered. All the guns in the vicinity should be turned on this point, firing against the Artillery and Infantry of the defenders which is impeding the advance. The guns more distant continue to fire on the hostile Artillery.

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There will be at this moment a probable check while awaiting the result of the Artillery fire. When the position appears to have been sufficiently cannonaded, orders will be given for the advance of the Infantry, and at the same time *all* Batteries should converge their fire on the point of attack and endeavour to keep down the fire of the enemy, while the nearer and more dangerous zones are being passed over. At this stage of the proceedings the Infantry skirmishers will be some 600 yards in front, while the reserves will be on a level with the line of guns, either on their flank or in the intervals between Batteries. As the Infantry Attack proceeds it is essential it should be accompanied by the Artillery. Even if the range be clear and the effect good it will be prejudicial to keep the guns too long in the *first Artillery position*. The modern Infantry Attack formations lead to a want of cohesion and a pressing necessity for an immediate and *moral* support which can only be afforded by the proximity of Artillery. The guns then have to advance, in order to support the Infantry, to their second position some 700 yards from the hostile line, and from it secure the success of the final assault or cover the retreat. The question of when to advance and by what stages is yet a matter of discussion, but as far as a general principle can be adhered to it may be fairly ruled, that between the first and second Artillery position there will generally be an intermediate one, that the changes will be made by movements in échelon, the guns moving direct to the front at their greatest speed in open order, and that the *time* for the change will be when the reserves of the first Infantry line pass the guns, and that the *point* moved to will be in proximity to the leading line of skirmishers.

In advancing from the first Artillery position all technical considerations must be sacrificed to the one object of assisting the Infantry in their Attack.

Assault of Position.

As the Infantry pass through the last zone of fire the supporting line closes on the skirmishers, the reserves of the first line gradually advance, and the second Infantry line of Attack comes under the heavy aimed fire of musketry. A strong element of confusion is inevitable. The feeding of the Attack with fresh troops becomes a necessity and the aid of support of all kinds imperative. A portion of the Batteries which have had their fire masked must follow up the Attack and be ready to come into action on the position itself.

The advance of Artillery to short ranges is in the case of success not so dangerous as would at first appear. The Artillery of the Defence if in action are fully occupied with the attacking Infantry, while the Infantry of the Defence which have not retired are at close quarters with their opponents. What has mainly to be feared is a counter-attack from the hostile reserves, in which event the guns in action will have to trust to case and reversed shrapnel.

When the Infantry Attack is checked and unable to progress it will

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be rarely possible for guns to advance beyond their second position, and from it they will have to sustain the Attack or cover the Retreat.

In the case of pursuit the amount of Artillery to follow up the enemy will depend on local circumstances, but the task will mainly fall on the Horse Artillery; and the Batteries detached must be specially guarded by escorts, and should strive by a rapid advance to gain positions on the flanks of the line of retreat.

Corps Artillery.

So far we have dealt with the attack of an independent force, or division acting independently. We have now to consider what happens if instead of one body with its attached Artillery, we have more than one body and an additional force of *Corps Artillery* which receives its orders direct from the Commander-in-Chief of the whole. It is useless to ignore the fact that the triple organization of our Army Corps complicates the question of the higher tactics of Artillery. The tactics of Corps Artillery are similar to those above noted, but its guns of necessity *come into action later*, and care must be taken to allow of *sufficient space for them to deploy in.*

In the most difficult case of an Army Corps on one route the Corps Artillery advances up to and deploys on *that flank of the guns in action* which is opposite the points of Attack. When two Advanced Guards are already engaged the Corps Artillery would usually occupy a *space between them.*

Assuming our Army Corps to be two divisions in first line with the third in support, it is difficult without breaking the tactical connection to see what to do with the Divisional Artillery of the third group. To carry out the views hitherto laid down it *may be* suggested that when an Attack is decided on, the Divisional Batteries of the third Division should be transferred to the *Corps Artillery*, while the *Horse Artillery Batteries* take their place with the Division and form with it a complete unit at the service of the Commander-in-Chief to be thrown into the fight at a vital moment.

Artillery on the Defence.

Owing to the enormous ranges of recently manufactured weapons, a great deal of ingenuity has been exercised in determining how an enemy can be destroyed at abnormal distances and, by the long range fire of Artillery and Infantry, demoralized before he can effectually deploy for action.

Especial attention has been directed to the value of the unaimed small-arm fire during the recent war, while by a somewhat inconsequent method of reasoning the value of long range Artillery fire, which has always existed, is but little noticed. The theories as to long range fire are the subject of much discussion, but without fully combating the

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opposite view, it may be suggested that the object of troops fighting whether on the offensive or defensive is in ordinary cases *victory*, and that victory cannot be gained except by the close conflict of masses. If the theory be true that an enemy is to be virtually defeated while out of sight, a new element has been introduced into warfare of which we have no practical knowledge. That fire at long ranges may under *special* circumstances be of value is undoubted, but in ordinary cases the lie of the ground, the existence of obstacles, and the necessity for husbanding ammunition forbid its use. While acting on the offensive the Artillery has to aid in carrying out an Attack on a pre-determined point; when on the defensive nothing is known as to the plan of the adversary, and dispositions must be made to meet every eventuality.

Position.

The position for the troops has been decided on general grounds and the Artillery must be placed on it in accordance with its special requirements. The great advantage is possessed of knowing all the ranges of the various points over which an enemy must pass, and that ample leisure is given for studying the best emplacements and protecting them by artificial means. It must be remembered that the *defensive fight* may have to be changed to an *offensive* one and that therefore the Batteries should be able to move forward in advance. The ground in rear should also be carefully reconnoitred so that the guns may know where to retire to in case of defeat.

At the commencement of a defensive fight an endeavour should be made to conceal the extent of the position and the manner in which it is occupied so that the assailants may prematurely expose their plans. The turning up of new earth for gun pits should therefore be moderately exercised, and the position of the gun emplacements be concealed as much as possible. The guns of the defending force should be kept some little way in rear of their entrenchments when cover admits of it, and run up by hand. In the very ordinary case where troops are disposed on commanding ground, with spurs running out to the front, it is generally recommended that the guns be placed in the re-entering angles and be protected by Infantry on the salient spurs. The existence of this idea shows how strongly the views of the *defensive* maintain their ground against the practical experience of war. If modern warfare teaches anything it is that the power of the guns should be developed to the utmost and that their place is in front line or even in advance of it. Hence, place the guns in front to obtain complete command, with wide lateral range, and protect them by pushing forward skirmishers.

First Phase of the Fight.

In considering the action of Artillery, on all occasions it must be remembered that when the Infantry is engaged it will always require

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the *moral* support of some guns, even if from a technical point of view the coming into action be a mistake. Tracing the course of a typical engagement we find that the enemy's Advanced Guard guns come into action, supported by his Infantry. At long range opposed to him would be the advanced posts or troops sent forward from the defensive position. The preliminary fight would take place between the Advanced Guard troops and the Advanced Infantry posts. The assailant next brings forward a large mass of guns to aid his Advanced Guard Batteries. According to the resistance offered, and the terrain, the first mass of guns will be formed up at *reconnoitring distance*, or advance at once to a first fighting position.

The first object of the defending Artillery will be to prolong the action of the Advance posts, hence the Advance Guard guns must be kept under a *fire sufficient to prevent* them doing much damage to the Advanced Infantry. A number of Horse Artillery Batteries detached to the front seems a preferable method, if possible, than unmasking the guns of main position. Nothing is more confusing to an enemy than to have the Artillery in two main fighting positions.

When the attacking guns first form up in reconnoitring position beyond the first zone of fire it will be generally injudicious to unmask more than a portion of the guns of the main position. Let the assailant under-estimate your strength; carefully watch his movements, and the moment he limbers up to advance to the *first fighting* position overwhelm him with the fire of every available gun.

The Artillery Duel.

In the great Artillery duel which ensues, there is a difference of opinion as to whether any of the guns of the defence should be kept in reserve. The matter seems to depend on the relative power of the two forces. A number of guns somewhat inferior to those of assailant should be able to prevent him obtaining the mastery. If the defender has more than these available they might with advantage be retained under cover, and reserve their fire till the Infantry Attack begins to be delivered. If the defence, however, is palpably inferior it should, by the deployment of every gun, delay as far as possible the final assault. In the event of *great inferiority*, when the Batteries are overwhelmed with concentric fire, it will be advisable to withdraw a considerable proportion of the guns under cover, and keep them ready to come into action against the Infantry when it advances. If it is not intended to hold the position to the last but simply to fight a delaying action in order to gain time, the whole force of the guns should be brought into action at the outset: commence firing at long ranges to force a distant deployment, and then withdraw by échelons before coming to close quarters with the hostile Infantry.

Progress of Action.

The assailant considering the Artillery duel sufficiently prolonged advances his Infantry. As soon as the second and third lines of

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supports become visible it will be evident in what manner the Attack will be delivered. Every gun of the reserve or otherwise now directs its shrapnel fire on the advancing Infantry, and strives to throw confusion in its ranks before it comes under the aimed fire of the defending Infantry. By the advance a portion of the assailant's Artillery fire will be masked, and his endeavour to gain a second position must be looked for, a certain number of guns being detailed to turn their fire on his Batteries when in movement.

However superior the enemy may be it will generally have been impossible for him to totally subdue the guns of the Defence. At the moment when the first advance of the Infantry Attack becomes evident all the Artillery of the Attacking Force will be concentrating their fire on the point of attack. The distant guns of the defence will therefore be able to play with effect on the advancing Infantry, and the fresh Infantry of the hitherto unengaged reserves will be brought up ready to repel the assault.

Again, as the point of attack becomes apparent, its vicinity should be reinforced by guns if available. In the case where a *reserve* of guns is kept in hand, they would, of course, be brought into action. When a reserve does not exist, an attempt should be made to withdraw a portion of the guns from points not threatened, and bring them to a more effective position.

The Assault.

As the Infantry attack progresses, the fire of the guns should be as rapid as possible, those that are masked by their own troops being pushed forward or retired in order to get a range. No guns should be taken out of action without the order of the General in command. The defensive powers of modern guns at short ranges with shrapnel and case is usually underrated, and a stubborn resistance may be made to the last moment. More especially will this be the case in the future. The efficacy of shrapnel at short ranges is being greatly increased: and there is a tendency to protect the gunners from fire at close quarters by some artificial means such as shields of wrought iron or steel. Where the fight is unequal the guns masked or silenced retire to a second position in order to cover the retirement or aid in a counter-attack with fresh troops.

Necessity for Horse Artillery.

The gradual increase which has of late years taken place in the mobility of Field Artillery has more than once raised the question as to the necessity of keeping up a force of Horse Artillery. The arguments on the subject may however be confined within narrow limits. The main conditions which a Field Artillery have to attain on service are (1) efficiency in fire, (2) quickness in movement. Any increase in the power of fire entails additional weight which naturally diminishes mobility. Assuming that both Horse and Field Batteries

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are similarly equipped, the latter have some 3 to 4½ cwt. in addition to carry in the shape of gunners. As a result the Horse Artillery with a similar efficacy of fire would have a superiority in mobility which should render them practically independent of the condition of the ground. Assuming the Horse Artillery to be provided with a gun of suitable weight, an additional 3 cwt. allows of a mobility in the equipment which is more than is wanted for the ordinary work of the battle-field, and a consequent further increase in weight is given to the Field gun to procure greater power of fire. To retain only one type of weapon and equipment must cause both efficacy of fire and mobility to the *extent now possessed* to be sacrificed. Efficacy of fire should not be diminished, as great power is now wanted to compensate for the increased range and effect of Infantry weapons. On the other hand it has been proved that the ordinary Field Battery cannot keep pace with Cavalry *except* for a very short time. Besides the value of mobility has increased. Not only have guns to accompany Cavalry Divisions in long and rapid marches but a distinct part where great mobility is requisite has arisen on the battle-field. The area of ground covered by troops both in Attack and Defence is now so large that to rapidly transfer Batteries to threatened and vital points, or to take part in wide ranging flank movements requires the greatest possible mobility. The extension of long lines of battle, the timely seizure of important tactical positions, the supporting of troops unexpectedly pressed, the carrying out of false attacks, the aiding in pursuit or the covering a retreat are also occasions in which Horse Artillery can with advantage play a part.

Tactics of Horse Artillery.

The actual tactics of Horse Artillery do not however differ from that of Field Batteries in the ordinary fight. What is lost in power is gained in time. The pace of movements is naturally quicker, and greater boldness in approaching an enemy can be shown. To study the distinctive peculiarities of the action of the lighter gun, the influence of the Infantry Arm must be eliminated and a study of an ordinary Cavalry engagement made. A Cavalry battle on a large scale may arise in two different ways: firstly, the two opposing screens of Cavalry which now precede Armies come into contact: secondly, the Cavalry of each side in a modern battle being unable to hold its own on the field moves off to a flank and encounters the enemy by mutual consent in a purely Cavalry engagement. The battle unit of Cavalry in such an engagement is the Division, which also appears to be the largest body of men who can be efficiently controlled by one leader when performing screening and reconnoitring duties in front of an Army.

Strength of a Division.

A Cavalry Division should consist of 6 Regiments divided for choice into three Brigades, to each of which is allotted a Battery. Of the

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Division two Brigades would ordinarily march in front line—detaching each a Regiment for an Advanced Guard—while the third Brigade follows in rear of the centre as a Reserve. The extent of front covered when near an enemy should not exceed 10 miles.

Position of Batteries.

On the march the three Batteries would march either with the Reserve Brigade or be divided, each Battery *following* the Advanced Guard of a Brigade.

In all cases, prior to the Cavalry battle, the guns must be massed under one leader. Take first the ordinary case of the Advanced Guard Action.

Battery of the Advanced Guard.

The mere fact of the exploring line having come in contact with the enemy is no reason for the Battery coming into action. When, however, there is a definite check the guns should gallop forward at once to *decisive range*, some 1,500 yards, and fire a few rounds while the supporting cavalry work away to the flanks. The Battery should go *straight to its front* and not work to a flank which might lead it into danger. In the event of the enemy not giving way the guns should *cease firing* and wait till the main body arrives, as it cannot afford to waste ammunition owing to the difficulty of replacing it.

Battery of the Rear Guard.

The action of the Horse Artillery does not differ materially from that of other Batteries with the following exceptions:—The resisting power of the Cavalry depends mainly on its *dismounted men*. As these cannot hold their ground long in the presence of Infantry the deployments of the enemy must be forced at a distance, hence the Batteries come into action *close behind* the dismounted men. Retiring to successive positions in rear must be effected at the *gallop*—as the Cavalry would be aware of the object of so doing, and the moral effect on them of a retreat would be slight. An *Artillery duel* with the enemy's guns should *never* be entered into.

The Cavalry Battle.

A Cavalry Division on the march would take from ¼ to ½ an hour to form up in fighting order, *i.e.*, in a front, supporting and reserve lines. While deploying, if the enemy's artillery is near at hand, the guns will have to come into action in front of, and on the flank of, the deployment in order to cover the movement.

After the Division is formed a decision has to be made as to the moment for Attack and the ground over which it will take place. The

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general line of Advance will then be pointed out to the Artillery Commander, whose guns during the action form the pivot of manœuvre for the Cavalry,

To utilize the power of the guns to the fullest they must strive to get into the *one position* from which they can fairly be supposed to act during all the phases of the battle. The guns have firstly to keep down the fire of the enemy's Artillery, then fire on the opposing Squadrons till the actual contact of the front lines on both sides takes place, then fire on the enemy's supports and reserves, and finally aid in pursuit or cover retreat. To attain this object the Artillery leader should estimate where the point of first conflict is likely to be, and strive to gain position 300 yards short of, and the same distance to, the flank of it.

It is best for the guns to advance straight to the front while the Cavalry makes a flank movement. The Batteries should come into action in échelon so that each Battery can rapidly change front on a central gun without limbering up. Against the enemy's squadrons common shell and case will be exclusively used.

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ON THE

MOTION OF A PROJECTILE IN A MEDIUM RESISTING AS THE CUBE OF THE VELOCITY.

BY

CAPT. P. A. MACMAHON, R.A.

THIS Paper may be regarded as a continuation of the one on the same subject contained in the last number of the "Proceedings," p. 231.

The expression for the abscissa of any point in the path of a projectile; viz.:—

$$x = \frac{w^2}{g}\int_p^a \frac{dp}{(3a + a^3 - 3p - p^3)^{\frac{1}{3}}} \quad \ldots \quad \ldots \quad (1)$$

was there considered, and it was shown that although the right-hand side of this equation is not integrable in finite terms, yet that the sum of three such integrals for values p_1, p_2, p_3 of p vanishes; provided only that a certain relation exists between p_1, p_2, p_3.

This relation was, in fact, found to be

$$(3a + a^3 - 3p_1 - p_1^3)\,(3a + a^3 - 3p_2 - p_2^3)\,(3a + a^3 - 3p_3 - p_3^3)$$
$$= \{3a + a^3 - p_1 - p_2 - p_3 - p_1 p_2 p_3\}^3;$$

or shortly,

$$P_1 P_2 P_3 = \{3a + a^3 - p_1 - p_2 - p^3 - p_1 p_2 p_3\}^3; \quad \ldots \quad \ldots \quad (2)$$

with Professor Greenhill's notation.

We may here observe that equation (2) may be written in the following irrational form, viz.:—

$$3a + a^3 + \left(\frac{p_2 P_1^{\frac{1}{3}} - p_1 P_2^{\frac{1}{3}}}{p_1 - p_2}\right) - p_1 p_2 p_3 \left[1 + \left(\frac{P_1^{\frac{1}{3}} - P_2^{\frac{1}{3}}}{p_1 - p_2}\right)^3\right] = 0 \quad (3)$$

from which p_3 is at once expressible explicitly in terms of p_1 and p_2.

This is analogous to what occurs in the theory of the resolution of algebraic equations; it is there found that it is possible to find algebraic expressions for many symmetric functions of the roots of equations, though these roots may not separately be so expressible.

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So we find that, under certain conditions, we can express the sum of a series of integrals, though it is impossible to evaluate each separately in finite terms. The Norwegian mathematician, Abel, considered this subject in his famous memoir, "*Sur une propriété générale d'une classe très étendue de fonctions transcendantes*," composed in 1826. The result of his researches was that—

If, for example,

$$\int X\,dx = F(x),$$

where X is any algebraic function of x, rational or irrational, integral or fractional; it is possible by connecting

$$x_1, x_2, x_3, \ldots\ldots x_n,$$

by certain algebraic laws, to obtain an expression, algebraic, or logarithmic, or circular, for the sum

$$F(x_1) + F(x_2) + \ldots\ldots + F(x_n).$$

In the case already considered, X assumed the form

$$(3a + a^3 - 3x - x^3)^{-\frac{2}{3}}$$

and we found that then

$$F(x_1) + F(x_2) + F(x_3) = 0,$$

provided that a single relation subsists between x_1, x_2, and x_3: in fact, the relation (2) given *ante*.

This might have been accomplished by Abel's theorem in the manner to be presently indicated.

Abel's theorem will enable us further to sum three integrals of the form

$$\int X\,dx,$$

where $X = x\,(3a + a^3 - 3x - x^3)^{-\frac{2}{3}}$,

or $X = (3a + a^3 - 3x - x^3)^{-\frac{1}{3}}$,

and since the ordinate and time integrals corresponding to (1) are

$$y = \frac{w^2}{g}\int_p^a \frac{p\,dp}{(3a + a^3 - 3p - p^3)^{\frac{2}{3}}}; \ldots \quad \ldots \quad \ldots \quad (4)$$

$$t = \frac{w}{g}\int_p^a \frac{dp}{(3a + a^3 - 3p - p^3)^{\frac{1}{3}}}; \ldots \quad \ldots \quad \ldots \quad (5)$$

we can find expressions

for $y_1 + y_2 + y_3$,

$t_1 + t_2 + t_3$,

in terms of a, p_1, p_2, and p_3, and for the summation desired to be effected, we must, as will be shown, have in each case

$$P_1 P_2 P_3 = \{3a + a^3 - p_1 - p_2 - p_3 - p_1 p_2 p_3\}^3.$$

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The theorem referred to may be found in the works of Abel, "*Œuvres Complétes*," and in a memoir by Professor Rowe, M.A., which has been recently read before the Royal Society. It would be out of place to give a complete account of it here, and we will as shortly as possible push on to Abel's result, and then proceed to apply it to the trajectory integrals.

We adopt Professor Rowe's notation to facilitate reference to his memoir, which will be found in the "Philosophical Transactions of the Royal Society," Part III., 1881, p. 713. Considering then the expression

$$\int X\,dx$$

we first introduce a new variable, y, which is connected with x by an equation

$$\chi(x, y) = 0\,; \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

where the form of χ for particular cases will afterwards appear.

χ being properly determined, the function X, whatever its form, may be written

$$f(x, y),$$

where f is a rational function of x and y. The subject of integration

$$f(x, y)$$

must now be transformed into the form

$$\frac{f_1(x, y)}{f_2(x)\chi'(y)}\,; \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

where f_1, f_2 are rational integral functions, and $\chi'(y)$ denotes the differential co-efficient of $\chi(x, y)$ with regard to y.

The form (7) will be used hereafter.

We must secondly form an equation whose roots are the variables of the functions we are summing. It is sufficient to take for this equation the result of eliminating y between the equation

$$\chi(x, y) = 0,$$

and an equation whose right hand member is zero, and whose left hand member is any other integral function of x and y.

Let this second equation be

$$\theta(x, y) = 0, \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (8)$$

This equation (8) is called the equation of condition, and the result of eliminating y between (6) and (8) is called the equation of the limits.

Let this be denoted by

$$E = 0\,; \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (9)$$

Any number of the coefficients in the equation

$$\theta(x, y) = 0,$$

are arbitrary; call them a_1, a_2, ... E is then a function of

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$x, a_1, a_2, \ldots\ldots$ and regarding $a_1, a_2 \ldots\ldots$ as absolute constants, we may take the roots of the equation

$$E = 0,$$

as the upper limits of our integrals, viewing these integrals as functions of these upper limits alone.

The final result obtained by Abel is that

$$\Sigma \int X\, dx = \Sigma \int \frac{f_1(x,y)}{f_2(x)\,\chi'(y)}\, dx$$

$$= \Theta\left[\frac{1}{f_2(x)}\right] \Sigma \frac{f_1(x,y)}{\chi'(y)} \log \theta(x,y) + C$$

where Σ indicates summation for the different values of y obtained by solving for y the equation

$$\chi(x,y) = 0,$$

C is a constant, and the meaning of the symbol Θ is thus defined by Professor Rowe in the memoir referred to:—"If $\phi(x)\, f(x)$ be any function of x composed of two factors $\phi(x)$, $f(x)$ whereof $\phi(x)$ is rational, let $\Theta[\phi(x)]\, f(x)$ denote the result obtained by successively developing the function in ascending powers of each simple factor $x-a$ in the denominator of $\phi(x)$, taking in each development the coefficient of $\frac{1}{x-a}$, adding together the coefficients thus obtained, and subtracting from the result the coefficient of $\frac{1}{x}$ in the development of the same function $\phi(x), f(x)$ in descending powers of x."

Abel gives the considerations which determine the forms of the functions

$$\chi(x,y) = 0, \qquad \theta(x,y) = 0,$$

but it is not necessary to enter on that subject here, and we proceed at once to the application of the theorem.

First, in the case of the abscissa integrals, we have

$$X = (3a + a^3 - 3x - x^3)^{-\frac{2}{3}} = \psi^{-\frac{2}{3}} \text{ suppose;}$$

where $\psi = 3a + a^3 - 3x - x^3$;

let $\chi(x,y) \equiv y^3 - \psi = 0 \quad \ldots \quad \ldots \quad \ldots \quad (10)$

so that $f(x,y) = X = \frac{1}{y^2}$;

and $\chi'(y) = 3y^2$,

therefore $f(x,y) = \frac{3}{\chi'(y)}$;

$$\therefore f_1(x,y) = 3, \qquad f_2(x) = 1.$$

Let also

$$\theta(x,y) \equiv y - a_1 - a_2 x = 0; \quad \ldots \quad \ldots \quad \ldots \quad (11)$$

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Eliminating y between (10) and (11) we find for the equation of the limits

$$E = \psi^{\frac{1}{3}} - a_1 - a_2 x = 0;$$

a cubic equation having three roots, which are the upper limits of the three integrals which we sum.

Suppose these roots to be x_1, x_2, x_3; ψ_1, ψ_2, ψ_3 being corresponding values of ψ;

Then

$$\left.\begin{aligned} \psi_1^{\frac{1}{3}} - a_1 - a_2 x_1 &= 0; \\ \psi_2^{\frac{1}{3}} - a_1 - a_2 x_2 &= 0; \\ \psi_2^{\frac{1}{3}} - a_1 - a_2 x_3 &= 0; \end{aligned}\right\} \quad \ldots \quad \ldots \quad (12)$$

Whence, eliminating the arbitrary constants a_1, a_2, between these three equations,

$$\psi_1^{\frac{1}{3}}(x_2 - x_3) + \psi_2^{\frac{1}{3}}(x_3 - x_1) + \psi_3^{\frac{1}{3}}(x_1 - x_2) = 0; \quad \ldots \quad \ldots \quad (13)$$

which is the expression of the requisite algebraic relation connecting x_1, x_2, x_3, when the summation

$$\int_0^{x_1} \frac{dx}{\psi^{\frac{2}{3}}} + \int_0^{x_2} \frac{dx}{\psi^{\frac{2}{3}}} + \int_0^{x_3} \frac{dx}{\psi^{\frac{2}{3}}}$$

can be effected.

Rationalising equation (13) we easily find it to be

$$\psi_1 \psi_2 \psi_3 = \{3a + a^3 - x_1 - x_2 - x_3 - x_1 x_2 x_3\}^3; \quad \ldots \quad \ldots \quad (14)$$

the equation before obtained by a different method.

Also

$$\Sigma \int X\, dx = \Theta \left[\frac{1}{1}\right] \Sigma \frac{3}{3y^2} \log \theta(x, y) + C,$$

$$= \Theta \left[1\right] \Sigma \frac{1}{y^2} \log (y - a_1 - a_2 x) + C,$$

$$= -\frac{C_1}{x} \Sigma \frac{1}{y^2} \log (y - a_1 - a_2 x) + C,$$

$\frac{C_1}{x}$ meaning the coefficient of $\frac{1}{x}$ in the term which follows.

Now the three values of y from equation (10) are

$$\omega^0 \psi^{\frac{1}{3}}, \ \omega^1 \psi^{\frac{1}{3}}, \ \omega^2 \psi^{\frac{1}{3}};$$

where ω is an imaginary cube root of unity.

So that

$$\Sigma \int X\, dx = -\frac{C_1}{x} \psi^{-\frac{1}{3}} \{\log (\psi^{\frac{1}{3}} - a_1 - a_2 x)$$

$$+ \omega \log (\omega \psi^{\frac{1}{3}} - a_1 - a_2 x) + \omega^2 \log (\omega^2 \psi^{\frac{1}{3}} - a_1 - a_2 x)\} + C = C; \quad \ldots \quad (15)$$

as will appear presently, when we work this expression out in considering the ordinate and time integrals.

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So that when the equation (14) is satisfied

$$\int_a^{x_1} \frac{dx}{\psi^{\frac{2}{3}}} + \int_a^{x_2} \frac{dx}{\psi^{\frac{2}{3}}} + \int_a^{x_3} \frac{dx}{\psi^{\frac{2}{3}}} = 0;$$

where $$\psi = 3a + a^3 - 3x - x^3,$$

the result before obtained.

Consider now the case in which

$$X = x\psi^{-\frac{2}{3}}$$

corresponding to the ordinate integral. The functions χ and θ are as before, leading to the same equation (14).

$$f(x,y) = X = \frac{x}{y^2} = \frac{3x}{\chi'(y)};$$

so that $$f_1(x,y) = 3x, \quad f_2(x) = 1;$$

and

$$\Sigma \int X\,dx = \Sigma \int \frac{f_1(x,y)}{f_2(x)\,\chi'(y)}\,dx;$$

$$= \Theta\left[\frac{1}{f_2(x)}\right] \Sigma \frac{f_1(x,y)}{\chi'(y)} \log \theta(x,y) + C,$$

$$= \Theta\left[1\right] \Sigma \frac{x}{y^2} \log (y - a_1 - a_2 x) + C,$$

$$= -C_{\frac{1}{x}} \left[x\psi^{-\frac{2}{3}} \{ \log (\psi^{\frac{1}{3}} - a_1 - a_2 x) \right.$$

$$\left. + \omega \log (\omega\psi^{\frac{1}{3}} - a_1 - a_2 x) + \omega^2 \log (\omega^2 \psi^{\frac{1}{3}} - a_1 - a_2 x)\} \right] + C; \quad \ldots \quad (16)$$

We have to expand the right hand side of this equation (16) in descending powers of x, so as to be able to pick out the coefficient of $\frac{1}{x}$. Consider first the terms within the brackets { };

since

$$\omega = -\frac{1}{2} + \sqrt{-1}\,\frac{\sqrt{3}}{2},$$

$$\omega^2 = -\frac{1}{2} - \sqrt{-1}\,\frac{\sqrt{3}}{2},$$

these terms are

$$\log (\psi^{\frac{1}{3}} - a_1 - a_2 x) - \tfrac{1}{2} \log \{ (\omega\psi^{\frac{1}{3}} - a_1 - a_2 x)(\omega_2 \psi^{\frac{1}{3}} - a_1 - a_2 x) \}$$

$$+ \sqrt{-1}\,\frac{\sqrt{3}}{2} \log \frac{\omega\psi^{\frac{1}{3}} - a_1 - a_2 x}{\omega^2 \psi^{\frac{1}{3}} - a_1 - a_2 x},$$

$$= \log (\psi^{\frac{1}{3}} - a_1 - a_2 x) - \tfrac{1}{2} \log \{\psi^{\frac{2}{3}} + (a_1 + a_2 x)\psi^{\frac{1}{3}} + (a_1 + a_2 x)^2\}$$

$$+ \sqrt{-1}\,\frac{\sqrt{3}}{2} \log \frac{a_1 + a_2 x - (-\frac{1}{2} + \sqrt{-1}\,\frac{\sqrt{3}}{2})\psi^{\frac{1}{3}}}{a_1 + a_2 x - (-\frac{1}{2} - \sqrt{-1}\,\frac{\sqrt{3}}{2})\psi^{\frac{1}{3}}},$$

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$$= \log\{1 - (a_1 + a_2x)\psi^{-\frac{1}{3}}\} - \tfrac{1}{2}\log\{1 + (a_1 + a_2x)\psi^{-\frac{1}{3}} + (a_1 + a_2x)^2\psi^{-\frac{2}{3}}\}$$
$$+ \sqrt{3}.\ \tfrac{1}{2}\sqrt{-1}\log\frac{\frac{2}{\sqrt{3}}(a_1 + a_2x) + \frac{1}{\sqrt{3}}\psi^{\frac{1}{3}} - \sqrt{-1}\,\psi^{\frac{1}{3}}}{\frac{2}{\sqrt{3}}(a_1 + a_2x) + \frac{1}{\sqrt{3}}\psi^{\frac{1}{3}} + \sqrt{-1}\,\psi^{\frac{1}{3}}},$$

$$= \log\{1 - (a_1 + a_2x)\,\psi^{-\frac{1}{3}}\} - \tfrac{1}{2}\log\{1 + (a_1 + a_2x)\psi^{-\frac{1}{3}} + (a_1 + a_2x)^2\psi^{-\frac{2}{3}}\}$$
$$+ \sqrt{3}\tan^{-1}\frac{\sqrt{3}\,\psi^{\frac{1}{3}}}{2(a_1 + a_2x) + \psi^{\frac{1}{3}}}, \quad \ldots \quad \ldots \quad \ldots \quad (17)$$

in virtue of the identity

$$\tfrac{1}{2}\sqrt{-1}\log\frac{1 - a\sqrt{-1}}{1 + a\sqrt{-1}} = \tan^{-1}a;$$

we now expand $(a_1 + a_2x)\psi^{-\frac{1}{3}}$, that is

$$(a_1 + a_2x)(3a + a^3 - 3x - x^3)^{-\frac{1}{3}},$$

in descending powers of x.

Put $$x = \frac{1}{\xi};$$

then $$(a_1 + a_2x)\psi^{-\frac{1}{3}} = (a_2 + a_1\xi)\{-1 - 3\xi^2 + (3a + a^3)\xi^3\}^{-\frac{1}{3}}$$
$$= -a_2 - a_1\xi + \text{terms involving higher powers of } \xi;$$

and $$(a_1 + a_2x)^2\psi^{-\frac{2}{3}} = a_2^2 + 2a_1a_2\xi + \ldots;$$

Therefore the logarithmic part of equation (17)

$$= \log(1 + a_2 + a_1\xi + \ldots.) - \tfrac{1}{2}\log\{1 - a_2 + a_2^2 + (2a_1a_2 - a_1)\xi + \ldots.\},$$

$$= \log(1 + a_2) + \log\left(1 + \frac{a_1}{1 + a_2}\xi + \ldots..\right)$$
$$- \tfrac{1}{2}\log(1 - a_2 + a_2^2) - \tfrac{1}{2}\log\left\{1 + \frac{2a_1a_2 - a_1}{1 - a_2 + a_2^2}\xi + \ldots.\right\},$$

$$= -\tfrac{1}{2}\log\frac{1 - a_2 + a_2^2}{(1 + a_2)^2} + \left\{\frac{a_1}{1 + a^2} - \tfrac{1}{2}\cdot\frac{2a_1a_2 - a_1}{1 - a_2 + a_2^2}\right\}\xi + \ldots.$$

The circular part of equation (17)

$$= \sqrt{3}\tan^{-1}\frac{\sqrt{3}\ \ \psi^{\frac{1}{3}}}{2(a_1 + a_2x) + \psi^{\frac{1}{3}}} = \sqrt{3}\cot^{-1}\left\{\frac{1}{\sqrt{3}} + \frac{2}{\sqrt{3}}(a_1 + a_2x)\,\psi^{-\frac{1}{3}}\right\},$$

$$= \pi\frac{\sqrt{3}}{2} - \sqrt{3}\tan^{-1}\left\{\frac{1}{\sqrt{3}} + \frac{2}{\sqrt{3}}(a_1 + a_2x)\,\psi^{-\frac{1}{3}}\right\},$$

$$= \pi\frac{\sqrt{3}}{2} - \sqrt{3}\tan^{-1}\left(\frac{1}{\sqrt{3}} - \frac{2}{\sqrt{3}}a_2 - \frac{2}{\sqrt{3}}a_1\xi + \ldots..\right),$$

$$= \pi\frac{\sqrt{3}}{2} - \sqrt{3}\tan^{-1}\left(\frac{1 - 2a_2}{\sqrt{3}}\right) - 2a_1\sin^2\left\{\cot^{-1}\frac{1 - 2a_2}{\sqrt{3}}\right\}\xi$$
$$+ \text{terms involving higher powers of } \xi.$$

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Therefore the right hand side of equation (17) becomes, when expanded in descending powers of x,

$$= -\tfrac{1}{2}\log\frac{1-a_2+a_2^2}{(1+a_2)^2} + \tan^{-1}\frac{\sqrt{3}}{1-2a_2}$$
$$+ \left\{\frac{a_1}{1+a_2} - \tfrac{1}{2}\frac{2a_1a_2-a_1}{1-a_2+a_2^2} - 2a_1\sin^2\left(\tan^{-1}\frac{\sqrt{3}}{1-2a_2}\right)\right\}\frac{1}{x}$$
$$+ \&c. \ldots\ldots ;$$

and since $$\psi^{-\frac{2}{3}} = \frac{1}{x^2} + \ldots\ldots ;$$

it is clear that the right hand side of equation (15) vanishes;

and $$\frac{C_1}{x}\, x\psi^{-\frac{2}{3}}\Sigma\log(\psi^{\frac{1}{3}} - a_1 - a_2x)$$
$$= -\tfrac{1}{2}\log\frac{1-a_2+a_2^2}{(1+a_2)^2} + \tan^{-1}\frac{\sqrt{3}}{1-2a_2}.$$

$$\therefore \Sigma\int X\,dx = \tfrac{1}{2}\log\frac{1-a_2+a_2^2}{(1+a_2)^2} - \tan^{-1}\frac{\sqrt{3}}{1-2a_2} + C; \ \ldots \quad \ldots \qquad (18)$$

Now from equation (12), *ante*:—

$$a_2 = \frac{\psi_1^{\frac{1}{3}} - \psi_2^{\frac{1}{3}}}{x_1 - x_2} = \frac{\psi_2^{\frac{1}{3}} - \psi_3^{\frac{1}{3}}}{x_2 - x_3} = \frac{\psi_3^{\frac{1}{3}} - \psi_1^{\frac{1}{3}}}{x_3 - x_1};$$

Therefore

$$\int^{x_1}\frac{x\,dx}{(3a+a^3-3x-x^3)^{\frac{2}{3}}} + \int^{x_2}\frac{x\,dx}{(3a+a^3-3x-x^3)^{\frac{2}{3}}} + \int^{x_3}\frac{x\,dx}{(3a+a^3-3x-x^3)^{\frac{2}{3}}}$$
$$= \tfrac{1}{2}\log\frac{(x_1-x_2)^3 + (\psi_1^{\frac{1}{3}}-\psi_2^{\frac{1}{3}})^3}{(x_1-x_2+\psi_1^{\frac{1}{3}}-\psi_2^{\frac{1}{3}})^3} - \cot^{-1}\left[\frac{1}{\sqrt{3}}\left(1 - 2\frac{\psi_1^{\frac{1}{3}}-\psi_2^{\frac{1}{3}}}{x_1-x_2}\right)\right] + C \quad \ldots \quad (19)$$

where $$\psi = 3a + a^3 - 3x - x^3.$$

The variables of this equation satisfy, of course, the relation expressed by (14); and since in that equation (14) we have $x_1 = x_2 = x_3 = a$ as one solution, we may, in order to determine the constant in (19), substitute these values. The expression of a_2 is then a vanishing fraction, and it may be shown to have the value infinity; viz.—

$$\frac{(3a + a^3 - 3x_1 - x_1^3)^{\frac{1}{3}} - (3a + a^3 - 3x_2 - x_2^3)^{\frac{1}{3}}}{x_1 - x_2} = \infty$$

in the limit, when

$$x_1 = x_2 = a.$$

And since $$\frac{1-a_2+a_2^2}{(1+a_2)^2} = \frac{\frac{1}{a_2^2} - \frac{1}{a_2} + 1}{\left(\frac{1}{a_2}+1\right)^2};$$

it is clear that, in this case, the right hand side of equation (19) vanishes, with the exception of the constant C.

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Thus $$C = 3\int^{a} \frac{x\,dx}{(3a + a^3 - 3x - x^3)^{\frac{2}{3}}};$$

and equation (19) becomes:—

$$\int_a^{x_1} \frac{x\,dx}{(3a+a^3-3x-x^3)^{\frac{2}{3}}} + \int_a^{x_2} \frac{x\,dx}{(3a+a^3-3x-x^3)^{\frac{2}{3}}} + \int_a^{x_3} \frac{x\,dx}{(3a+a^3-3x-x^3)^{\frac{2}{3}}}$$

$$= \tfrac{1}{2}\log \frac{(x_1-x_2)^3 + (\psi_1^{\frac{1}{3}}-\psi_2^{\frac{1}{3}})^3}{(x_1-x_2+\psi_1^{\frac{1}{3}}-\psi_2^{\frac{1}{3}})^3} - \cot^{-1}\left[\frac{1}{\sqrt{3}}\left(1 - 2\,\frac{\psi_1^{\frac{1}{3}}-\psi_2^{\frac{1}{3}}}{x_1-x_2}\right)\right] \ldots \quad \ldots (20)$$

Next consider the case in which

$$X = \psi^{-\frac{1}{3}};$$

corresponding to the time integral.

Taking the functions χ and θ as before,

$$X = f(x,y) = \frac{1}{y} = \frac{3y}{\chi'(y)};$$

so that $$f_1(x,y) = 3y, \quad f_2(x) = 1.$$

and

$$\Sigma\int X\,dx = \Theta\left[1\right]\Sigma\frac{1}{y}\log(y - a_1 - a_2x) + C,$$

$$= -\frac{C_1}{x}\psi^{-\frac{1}{3}}\sum_{n=2}^{n=0}\frac{1}{\omega^n}\log(\omega^n\psi^{\frac{1}{3}} - a_1 - a_2x) + C,$$

$$= -\frac{C_1}{x}\psi^{-\frac{1}{3}}\left[\log(\psi^{\frac{1}{3}} - a_1 - a_2x) + \omega^2\log(\omega\psi^{\frac{1}{3}} - a_1 - a_2x)\right.$$

$$\left. + \omega\log(\omega^2\psi^{\frac{1}{3}} - a_1 - a_2x)\right] + C;$$

The part within the bracket, on the right hand side of this equation is equal to:—

$$\log(\psi^{\frac{1}{3}} - a_1 - a_2x) - \tfrac{1}{2}\log\{(\omega\psi^{\frac{1}{3}} - a_1 - a_2x)(\omega^2\psi^{\frac{1}{3}} - a_1 - a_2x)\}$$

$$- \sqrt{-1}\,\frac{\sqrt{3}}{2}\tan^{-1}\frac{\omega\psi^{\frac{1}{3}} - a_1 - a^2x}{\omega^2\psi^{\frac{1}{3}} - a_1 - a_2x};$$

This is the same as the expression we expanded before in considering the summation of the ordinate integrals, with the exception of the sign of the circular part, which is now negative; since, therefore, the first term of the descending expansion of $\psi^{-\frac{1}{3}}$ is

$$-\frac{1}{x},$$

we have, from previous work:—

$$\int^{x_1} \frac{dx}{(3a+a^3-3x-x^3)^{\frac{1}{3}}} + \int^{x_2} \frac{dx}{(3a+a^3-3x-x^3)^{\frac{1}{3}}} + \int^{x_3} \frac{dx}{(3a+a^3-3x-x^3)^{\frac{1}{3}}}$$

$$= -\tfrac{1}{2}\log\frac{(x_1+x_2)^3-(\psi_1^{\frac{1}{3}}-\psi_2^{\frac{1}{3}})^3}{(x_1-x_2+\psi_1^{\frac{1}{3}}-\psi_2^{\frac{1}{3}})^3} - \cot^{-1}\left[\frac{1}{\sqrt{3}}\left(1 - 2\,\frac{\psi_1^{\frac{1}{3}}-\psi_2^{\frac{1}{3}}}{x_1-x_2}\right)\right] + C \quad \ldots (21)$$

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Determining the constant as before, we arrive at the equation :—

$$\int_a^{x_1} \frac{dx}{(3a+a^3-3x-x^3)^{\frac{1}{3}}} + \int_a^{x_2} \frac{dx}{(3a+a^3-3x-x^3)^{\frac{1}{3}}} + \int_a^{x_3} \frac{dx}{(3a+a^3-3x-x^3)^{\frac{1}{3}}}$$

$$= -\tfrac{1}{2} \log \frac{(x_1-x_2)^3-\psi_1^{\frac{1}{3}}-\psi_2^{\frac{1}{3}})^3}{(x_1-x_2+\psi_1^{\frac{1}{3}}-\psi_2^{\frac{1}{3}})^3} - \cot^{-1}\left[\frac{1}{\sqrt{3}}\left(1-2\frac{\psi_1^{\frac{1}{3}}-\psi_2^{\frac{1}{3}}}{x_1-x_2}\right)\right] \quad \ldots \quad \ldots \quad (22)$$

which is the formula for the summation of the time integrals.

It remains to apply these results directly to the curve of flight.

Using Professor Greenhill's notation (Vol. XI., p. 133) from equation (4) :—

$$y_1 + y_2 + y_3 = -\frac{w^2}{g}\left\{\int_a^{p_1} \frac{p\,dp}{P^3} + \int_a^{p_2} \frac{p\,dp}{P^3} + \int_a^{p_3} \frac{p\,dp}{P^3}\right\}$$

$$= \frac{w^2}{g}\left[-\tfrac{1}{2}\log\frac{(p_1-p_2)^3-(P_1^{\frac{1}{3}}-P_2^{\frac{1}{3}})^3}{(p_1-p_2+P_1^{\frac{1}{3}}-P_2^{\frac{1}{3}})^3} + \cot^{-1}\left\{\frac{1}{\sqrt{3}}\left(1-2\frac{P_1^{\frac{1}{3}}-P_2^{\frac{1}{3}}}{p_1-p_2}\right)\right\}\right] \quad (23)$$

similarly from equation (5) :—

$$t_1 + t_2 + t_3 = -\frac{w}{g}\left\{\int_a^{p_1} \frac{dp}{P^3} + \int_a^{p_2} \frac{dp}{P^3} + \int_a^{p_3} \frac{dp}{P^3}\right\}$$

$$= \frac{w}{g}\left[+\tfrac{1}{2}\log\frac{(p_1-p_2)^3-(P_1^{\frac{1}{3}}-P_2^{\frac{1}{3}})^3}{(p_1-p_2+P_1^{\frac{1}{3}}-P_2^{\frac{1}{3}})^3} + \cot^{-1}\left\{\frac{1}{\sqrt{3}}\left(1-2\frac{P_1^{\frac{1}{3}}-P_2^{\frac{1}{3}}}{p_1-p_2}\right)\right\}\right] \quad (24)$$

where it is understood that equations (23) and (24) are true only when

$$P_1 P_2 P_3 = (3a + a^3 - p_1 - p_2 - p_3 - p_1 p_2 p_3)^3 .$$

The ordinates and times are measured from the point where the velocity is infinite to the points where the tangents to the trajectory are inclined to the horizontal at the angles

$$\tan^{-1} p_1 , \qquad \tan^{-1} p_2 , \qquad \tan^{-1} p_3 .$$

w is the terminal velocity, equal to

$$\left(\frac{gW}{K\bar{d}^2}\right)^{\frac{1}{3}} . \ 1000 ,$$

in Mr Bashforth's notation.

From (23) and (24) we find :—

$$y_1 + y_2 + y_3 + w(t_1 + t_2 + t_3) = 2\,\frac{w^2}{g}\cot^{-1}\left\{\frac{1}{\sqrt{3}} - \frac{2}{\sqrt{3}}\frac{P_1^{\frac{1}{3}}-P_2^{\frac{1}{3}}}{p_1-p_2}\right\} \ldots \quad (25)$$

a remarkable relation.

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Representing by $(y)^m_n$, $(t)^m_n$, the ordinate and the time between the points of the path, where at p is equal to m and n respectively, the following relations are easily deduced by the method employed in the previous paper, viz. :—

$$\frac{g}{w^2}\left\{(y)^{0}_{a}+(y)^{2a+a^3}_{a}\right\}=-\tfrac{1}{2}\log\frac{3a}{\{(3a+a^3)^{\frac{1}{3}}-a\}^3}+\cot^{-1}\left\{\frac{1}{\sqrt{3}}+\frac{2}{\sqrt{3}}\left(1+\frac{3}{a^2}\right)^{\frac{1}{3}}\right\}\quad\ldots\quad\ldots\quad\ldots\quad(26)$$

$$\frac{g}{w}\left\{(t)^{0}_{a}+(t)^{2a+a^3}_{a}\right\}=+\tfrac{1}{2}\log\frac{3a}{\{(3a+a^3)^{\frac{1}{3}}-a\}^3}+\cot^{-1}\left\{\frac{1}{\sqrt{3}}+\frac{2}{\sqrt{3}}\left(1+\frac{3}{a^2}\right)^{\frac{1}{3}}\right\}\quad\ldots\quad\ldots\quad(27)$$

$$\frac{g}{w^2}\left\{(y)^{\frac{1}{3}(3a+a^3)}_{a}+(y)^{3+3a^2+a^4}_{a}\right\}=-\tfrac{1}{2}\log\tfrac{1}{3}(3+3a^2+a^4)+\cot^{-1}\left\{\frac{\sqrt{3}}{a^2}(2+a^2)\right\}\quad\ldots\quad\ldots\quad\ldots\quad(28)$$

$$\frac{g}{w}\left\{(t)^{\frac{1}{3}(3a+a^3)}_{a}+(t)^{3+3a^2+a^4}_{a}\right\}=+\tfrac{1}{2}\log\tfrac{1}{3}(3+3a^2+a^4)+\cot^{-1}\left\{\frac{\sqrt{3}}{a^2}(2+a^2)\right\}\quad\ldots\quad\ldots\quad\ldots\quad(29)$$

$$\frac{g}{w^2}\left\{2(y)^{0}_{a}+(y)^{\frac{3(3a+a^3)}{1-(3a+a^3)^2}}_{a}\right\}=-\tfrac{1}{2}\log\frac{(3a+a^3)^2-1}{\{(3a+a^3)^{\frac{1}{3}}-1\}^3}+\cot^{-1}\left\{\frac{1}{\sqrt{3}}+\frac{2}{\sqrt{3}}(3a+a^3)^{\frac{1}{3}}\right\}\quad\ldots\quad\ldots\quad(30)$$

$$\frac{g}{w}\left\{2(t)^{0}_{a}+(t)^{\frac{3(3a+a^3)}{1-(3a+a^3)^2}}_{a}\right\}=+\tfrac{1}{2}\log\frac{(3a+a^3)^2-1}{\{(3a+a^3)^{\frac{1}{3}}-1\}^3}+\cot^{-1}\left\{\frac{1}{\sqrt{3}}+\frac{2}{\sqrt{3}}(3a+a^3)^{\frac{1}{3}}\right\}\quad\ldots\quad\ldots\quad(31)$$

It is interesting to compare equations (23), (24), and (25), above, with results easily deduced from the paper by Professor Greenhill, before-mentioned, since it leads to a very curious Theta function identity. It will be remembered that therein x is the argument of the elliptic functions corresponding to the abscissa x; in fact,

$$\mathrm{x}=\frac{g}{w^2}\frac{(4+a^2)^{\frac{1}{4}}(4+4a^2)^{\frac{1}{4}}}{3^{\frac{1}{4}}}x,$$

whilst a is such that

$$\frac{\mathrm{sn}^2\mathrm{a}\,\mathrm{dn}^2\mathrm{a}}{(1-\mathrm{cn}\,\mathrm{a})^4}=\frac{a^2}{4\sqrt{3}(4+a^2)}.$$

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Then from the expressions given on pp. 598, Vol. XI., and 19, Vol. XII., we have since $x_1 + x_2 + x_3 = 0$;

$$\frac{g}{w^2}(y_1 + y_2 + y_3) = \Sigma \log \frac{\Theta_1 \frac{1}{2}(a + x)\ \Theta_3 \frac{1}{2}(a + x)}{\Theta_1 \frac{1}{2} a\ \Theta_3 \frac{1}{2} a}$$

$$+ \omega \Sigma \log \frac{\Theta_1 \frac{1}{2}(\omega a + x)\ \Theta_3 \frac{1}{2}(\omega a + x)}{\Theta_1 \frac{1}{2}\omega a\ \Theta_3 \frac{1}{2}\omega a} + \omega^2 \Sigma \log \frac{\Theta_1 \frac{1}{2}(\omega^2 a + x)\ \Theta_3 \frac{1}{2}(\omega^2 a + x)}{\Theta_1 \frac{1}{2}\omega^2 a\ \Theta_3 \frac{1}{2}\omega^2 a}$$

where the symbol Σ refers to summation for the values x_1, x_2, x_3 of the argument x, and ω, ω^2 are the imaginary cube roots of unity.

Also

$$\frac{g}{w}(t_1 + t_2 + t_3) = \Sigma \log \frac{\Theta_1 \frac{1}{2}(a + x)\ \Theta_3 \frac{1}{2}(a + x)}{\Theta_1 \frac{1}{2} a\, \Theta_3 \frac{1}{2} a}$$

$$+ \omega^2 \Sigma \log \frac{\Theta_1 \frac{1}{2}(\omega a + x)\ \Theta_3 \frac{1}{2}(\omega a + x)}{\Theta_1 \frac{1}{2}\omega a\ \Theta_3 \frac{1}{2}\omega a}$$

$$+ \omega \Sigma \log \frac{\Theta_1 \frac{1}{2}(\omega^2 a + x)\ \Theta_3 \frac{1}{2}(\omega^2 a + x)}{\Theta_1 \frac{1}{2}\omega^2 a\ \Theta_3 \frac{1}{2}\omega^2 a};$$

whence comparing these two equations with our equation (25), the identity follows, viz.:—

$$\sqrt{-1}.\sqrt{3}.\log\left[\frac{\Theta_1 \frac{1}{2}(\omega a + x_1)\ \Theta_1 \frac{1}{2}(\omega a + x_2)\ \Theta \frac{1}{2}(\omega a + x_3)}{\Theta_1 \frac{1}{2}(\omega^2 a + x_1)\ \Theta \frac{1}{2}(\omega^2 a + x_2)\ \Theta \frac{1}{2}(\omega^2 a + x_3)}\cdot\right.$$

$$\left.\cdot\frac{\Theta_3 \frac{1}{2}(\omega a + x_1)\ \Theta_3 \frac{1}{2}(\omega a + x_2)\ \Theta_3 \frac{1}{2}(\omega a + x_3)\ \Theta_1 \frac{1}{2}\omega^2 a\ \Theta_3 \frac{1}{2}\omega^2 a}{\Theta_3 \frac{1}{2}(\omega^2 a + x_1)\ \Theta_3 \frac{1}{2}(\omega^2 a + x_2)\ \Theta_3 \frac{1}{2}(\omega^2 a + x_3)\ \Theta_1 \frac{1}{2}\omega a\ \Theta_3 \frac{1}{2}\omega a}\right]$$

$$= 2\cot^{-1}\left\{\frac{1}{\sqrt{3}} - \frac{2}{\sqrt{3}}\frac{P_1^{\frac{1}{3}} - P_2^{\frac{1}{3}}}{p_1 - p_2}\right\};$$

the condition being that $x_1 + x_2 + x_3$ vanishes, and the connection between p and x being expressed by the equation

$$\operatorname{cn} x = \frac{(4 + 4a^2)^{\frac{1}{3}} P^{\frac{1}{3}} - (\sqrt{3} + 1)(4 + a^2)^{\frac{1}{3}}(a - p)}{(4 + 4a^2)^{\frac{1}{3}} P^{\frac{1}{3}} + (\sqrt{3} - 1)(4 + a^2)^{\frac{1}{3}}(a - p)}.$$

The direct verification of this identity would be very tedious.

Abel's theorem will enable us also to find the algebraic laws necessary for the summation of any larger number of the trajectory integrals considered above.

This may form the subject of a future paper.

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THE EFFECTS

OF THE

INCREASED POWERS OF INFANTRY WEAPONS.

BY

CAPT. R. F. JOHNSON, R.A.

Of all the military questions which now present themselves for discussion and decision, the most interesting and most pressing seems to be that of the development and use of the powers of the modern infantry weapons. On this all other points seem to depend. It affects the organization and drill of all Arms, their tactics, and their equipment.

If the Germans had not been successful in the War of 1870, the terrible losses sustained by them, and their frequent local repulses, must have brought the conviction to all minds, that the long range of rifles would necessitate great modifications in tactics, and none would have been bold enough to advocate an advance without firing to close ranges, or to attempt to use the "*arme blanche*" before adequate preparation.

St. Privat showed the futility of direct attack on fairly disciplined troops; many instances of the Russo-Turkish war point to the same thing, and in this case the Defence had no fire discipline. We read of instances in 1878, where losses commenced at 3000 yards, were considerable at 2000, and overwhelming at closer quarters.

Tactics are affected firstly by the great increase of all former distances, and the consequently greater time required for manœuvring. The offensive gains by; (1) The participation of the infantry in the preparation of the Attack. (2) The greater distance from the line that the reserves of the Defence must be at. (3) The increased opportunities of outflanking positions from greater distances, and the greater length of line affected by the enfilading fire. (4) The decreased cover afforded by entrenchments, &c., owing to the angle of drop of the trajectories. (5) The ability to keep the defender's reconnaissances at a distance, and so conceal turning movements, or the positions of the reserves. The defensive, on the other hand, has great gains in; (1) The distance an attacker is forced to deploy at. (2) The increased zone of fire that has to be passed. (3) The greater chance of discovering movements in time to meet them. (4) The greater rapidity of the fire, and the difficulty of dislodging any body, however

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small, when once it has seized a post. (5) The extent of front that can be occupied, from the facility with which open ground can be defended by cross fire alone. This last is a very great advantage.

To what do these facts point? Is it not to the necessity for still greater mobility, and a more efficient supply of munitions of war, combined with strict discipline and increased instruction?

Infantry.

If we turn to Russian writers, we find much difference of opinion on the lessons of their last war.

General Tchebicheff deprecates loose dispersion and much depth, and takes as his ideal a single strong line advancing continuously firing always. He is obliged however to admit of secondary lines for various purposes, but maintains that they must increase the losses.

Colonel Kourapatkin disagrees with his arguments and deductions, advocates dispersion, several lines, advances by rushes, and more or less continuous fire.

Captain Schur prefers continual advances, bringing instances from the war in Armenia to support the assertion that more losses were suffered during periods of rest than those of motion, and declaring, as seems very true, that much halting to fire demoralises troops, and makes them loth to advance. The latter idea is seemingly endorsed by De Brack in his Reminiscences, for, in speaking of cavalry charges, he says a little previous exposure (*i.e.*, without reply) braces up the men's nerves, and makes them desirous of getting to the enemy.

There can be no doubt that a steady advance without firing is very imposing, and likely to affect the defender's moral, but it is now an impossibility.

The zone of losses now commences at 3000 paces or thereabouts; the object of the attacker must be to get across this zone as fast as he can. If his troops fire the whole way, they must be delayed, their ammunition must be considerably diminished, and it will require a very good spirit, or the continual bringing up of fresh supports, to carry the first line across the distance without serious halts. After each halt an entirely fresh start has to be made, an impulse for which has to be sought in the example, and hence exposure, of the officers or the addition of fresh men to the line. While advancing, the firing of the men must be left more or less to them, and beyond 1000 yards will be excessively erratic. A position having been carried, the troops taking it must have plenty of ammunition to meet counter attacks. It is found that after a certain zone is passed the losses do not increase but rather diminish in the front line, which may be attributed to the defender's not exposing themselves, and so firing high over the parapets. Experiments have shown that at long ranges, from the large angles of drop of their projectiles, rifles and machine-guns have great searching power, *i.e.*, at long ranges entrenchments have a diminished value. The Martini-Henry bullet at 3000 yards retains sufficient velocity to disable a man.

How are these facts to be met and utilised?

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Frontal attacks must be only resorted to in peculiar circumstances. Flank manœuvres as they have become necessary have also become more possible, from the power troops have of holding positions once seized, and thus barring the way to rapid counter attacks while the flank movements are being developed. It is not necessary as a rule to hold an enemy in front by a vigorous offensive, for a demonstration will affect the purpose as well, compelling the deployment of the defender's forces, and rendering it difficult for him to disengage them.

For the attack the following is the tactical conduct proposed:—

Certain troops to be told off to prepare the attack. These acting somewhat after the manner of artillery would push forward as far as permitted, and taking up favourable positions in small bodies (say a British company) would assist the artillery in the preparation, keeping up a continuous fire until passed and masked by the other infantry. If machine-guns are taken to the field, their place is with these advanced parties.

The real attacking force to be kept out of the range of serious loss until the preparation is apparently complete, and then to advance in close line formation with intervals, but with secondary lines at considerable distances without firing until abreast of the preparing parties, every cover afforded by the ground being taken advantage of. When they arrive abreast of the advanced parties they should open out to gain room to fire and form a continuous line. Between 1000 and 600 yards they should commence to fire and keep up a continuous fire, halting as seldom as possible. Supports, &c., must be ready to assist them when the position is taken.

With regard to the preparing parties it would seem advisable to have them formed by special troops, trained to long range fire.[1] Volleys seem better than independent firing for them. The men are kept cooler, the range and effect can be better ascertained. Would three ranks be a good formation for volley firing with three different heights of sights?

Just as the long ranges of modern rifles might be advantageously employed by training special companies or battalions, corresponding to the light troops of former days, in its use; so might the powers of magazine rifles be employed by giving them to companies or battalions corresponding to the former grenadiers. These latter on the offensive would reinforce the line at critical points, and occupy positions seized in order to repel the immediate and most dangerous counter-attacks; on the defensive they would reinforce points, where the front showed signs of wavering, and form the last reserve. If the remaining companies of a battalion were trained to shoot without raising the sights, it is possible that better results would be obtained *in action* than there are at present.

The continuous firing of the advancing attack may not be very efficacious, but it is impossible to prevent; it enlivens the men, hides

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[1] "Unaimed" is a misnomer for this kind of firing calculated to have the same effect as the use of the term "branding" for "tattooing." Why not "Curved" or "High-angled Infantry Fire?"

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them from the enemy and must have a moral effect, as only a steady line of flashes and smoke can be seen continuously advancing with no perceptible losses.

Mobility must be secured by lightening the men's loads, carrying their kits for them, &c.; and by the supply of ammunition being always kept up with the troops. To ensure the latter a first line of bat animals seems very good. Baker Pasha bears witness to the efficacy of the system in the Turkish Army. Cannot we do as well as the Turks?

It is true that the Germans decreased their stock of ammunition after 1870, but we have two witnesses of the necessity of increasing it, who were on opposite sides in the 1878 campaign. Baker says that the Turkish soldier carried 100 rounds on his person, and considers this amount absolutely necessary. General Zeddeler recommends strongly that each man should have 200 rounds immediately available, 105 being on his person.

For long range firing, would not some graduated instrument, with a small spirit-level or plumb-line, to enable a rifle to be fired mechanically like a field gun at known ranges be advisable? Firing once begun, there is little seen to aim at.

On the side of the Defence the object is to accumulate fire on the approaches and keep it up. Advanced posts can be held at greater distances from the main line so as to compel the deployment of the Attack. Fewer men can be used to occupy a position, unimportant parts being defended by indirect fire. Von Schellendorf gives 8 men per metre which is 6,772 for 1000 yards of front; the English Field Exercise 5 per pace. If one is taken to represent the front of spots actually occupied, and the other that of the whole position, they approach agreement. Both, however, would only seem to apply to large forces, small ones being amply provided for by three rifles to a pace.

Artillery also is affected by long range infantry fire. It cannot be certain of approaching to anything like close quarters as it did in 1870. It must be more manœuvred, and it seems clearly proved that batteries can be moved under fire and still remain sufficiently mobile. An important want, however, is a "horse reserve," for immense losses are sustained, and though, after a battle, a battery may be mobile enough to fight, it cannot march far. It is fatal also to take the horses of the Ammunition Reserve Columns so often done in 1870. In favorable ground 4 horses might easily work a light gun, and the rest of the team might be placed under cover.

The *artillery of the Attack* must now, as before, be concentrated at the commencement of an action so as to ensure the superiority, but later on it can manœuvre more, and by judicious use of ground, &c., endeavour to neutralise the advantage gained by the increased range of the rifle.

It can now more than before devote itself to the crushing of the artillery of the Defence and the overwhelming of material obstacles, leaving the infantry more to the care of the infantry.

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The range of the rifle being about 2500, and that of the last guns being 3000 yards, the zone between these seems the most suitable for the guns.[1] For the moral effect on one's own side, however, some guns must advance with the infantry line as far as possible, and it must be remembered that the material effect increases in a large ratio as the range diminishes.

As eyesight limits the extent of range, and generally the configuration of the ground also, to about 3000 yards, it does not seem desirable to seek any increase of range in the field gun, but increase of calibre would go far towards restoring to Artillery its relative power, and howitzers weighing the same as the present gun, and throwing shells containing twice as many bullets would probably give sufficient accuracy for shell fire.

The *artillery of the Defence* must at first be scattered and in reserve, but must concentrate at once, when the Attack developes. For this purpose, emplacements must be prepared at all likely points, or else the artillery of the Attack will crush it as it comes up, or the preparatory infantry will drive it away. It can now devote more of its time to the reserves of the Attack, leaving the skirmishers to the infantry.

The mobility of Artillery would be much increased if the Commanders were relieved from the fear of surprise. Cavalry can only assist a battery suddenly attacked if it is superior to the adversary, and with infantry there is the difficulty of movement and perhaps a want of agreement between the Officer Commanding Royal Artillery and the Officer Commanding the escort.[2] Much might be achieved if each Division of Artillery of three Batteries had belonging to it a rifle squad of (say) 50 men formed of and commanded by Artillerymen. They could be carried on 3 or 4 wagons—with seats outwards like an Irish car—drawn by 4 horses each. They would be of great assistance with the guns in difficulties; could move with the batteries; would be under the control of, and appreciate the movements of the Officer Commanding, and with them no Battery Commander need fear surprise, or dread an encounter with the scouting parties of the enemy.

Cavalry in large bodies seems less likely to achieve any success in battle against the other Arms than ever, but is more important than it has ever been as the eyes and screen of the army. It has great mobility, hence it requires an equipment to enable it to act separately (*i.e.*, rifle and pioneer equipment), and training in its use.[3] Small

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[1] 3000 yards is a *very effective range* now.

[2] The same remark may be made concerning the carriage of infantry ammunition by the artillery.

[3] The *rôle* of large bodies of cavalry in a battle will be to watch the flanks and to keep like bodies of the enemy in check. One of the problems in tactics still unsolved is, how to derive in cavalry combats on a large scale the greatest possible benefit from the fire of the Horse Artillery. The chief characteristics of these combats are; the time for their preparation is very short and the ranges vary rapidly but are not long. Machine guns (of which the projectiles require no fuzes, and the laying can be altered while the firing goes on), might be the best armament for the Horse Artillery batteries *attached to cavalry brigades.*

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bodies of heavy cavalry, well handled, will, however, have opportunities of acting most usefully by surprise on the field of battle, opportunities all the greater because less expected than formerly.

Mounted Infantry,[1] pure and simple, with rifle and bayonet but no sword or spurs, mounted on galloways, not horses, I cannot help thinking to be an important Arm of the future, especially in small armies like our own. It can scout and it can fight when required. Cavalry can sometimes gain time by charging; could not Mounted Infantry gain more by appearing unexpectedly at the right point? In these days of great distances and flank manœuvres who can tell what might not be achieved by a General who had 5000 rifles which he could transfer to any part of the field with great rapidity. Forage is a difficulty? Reduce the Cavalry and Artillery.

Everything seems to point to, and require, rapidity, mobility, manœuvre.

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[1] The Mounted Infantry in the last campaigns, as far as one has heard as yet, was employed rather as cavalry than as infantry. They were of great use thus, but cavalry would probably have been of greater. The raising of this Arm on the outbreak of war has the same drawbacks, only intensified, as the filling up of battalions with transfers and volunteers. The officers and men are not acquainted with each other, and both are, as a rule, unused to the management of large numbers of horses. The last fact necessitates the employment in the Arm of cavalry officers, which cannot be advisable, as the fighting should be that of infantry. The only horse training required is that which is sufficient to enable the men to ride fairly, and to know something of horse management. Fifty galloways kept at Aldershot would enable at least four complete companies to be trained each year, who would be available for campaigning during the year or two next following.

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NOTE

ON

"NORMAN RAMSAY'S EXPLOIT."

BY

CAPTAIN K. STEPHENSON, R.H.A.

I FEEL bound to call attention to a clerical error (which I trust will be corrected) in an article by the Secretary, in the last number of the "Proceedings," Vol. XII., p. 203, "Norman Ramsay's Exploit."

At Fuentes d'Onor Norman Ramsay was in command of I Troop (now I/A, quartered at Canterbury), of which he was 2nd Captain. Bull, whose Troop it was, appears to have been employed on the Staff throughout nearly the whole of the Peninsular War, consequently I Troop was always commanded by Ramsay.

Ross and Bull's Troops (A and I) were the only two Horse Artillery Troops present at Fuentes d'Onor. E Troop (Macdonald's) does not appear to have arrived in Spain before the autumn of 1811, and therefore could not have been present at the battle.

Although A and I seem to have been the only two Troops of Horse Artillery ever mentioned by the Duke of Wellington in his despatches, still E's roll of Active Service in Spain, at Waterloo, and in India is sufficiently long to require no false lustre from borrowed plumes.

I may mention that the 5th May always used to be, and I believe still is observed as a half holiday in I/A, and in no Battery is there stronger *esprit de corps* among all ranks of those who have ever served in it, as may be seen by the happily successful efforts that were made to save it from being reduced, when ordered home for that purpose from India, last year.

[Norman Ramsay's Troop undoubtedly was Bull's, or "old I Troop," as Captain Stephenson says; and not "old E Troop," as I mis-called it. I cannot, however, take advantage of the silver bridge suggested by Captain Stephenson's kindly phrase—"clerical error." The blunder was no clerical error, but one of sheer ignorance.—*H.W.L.H.*]

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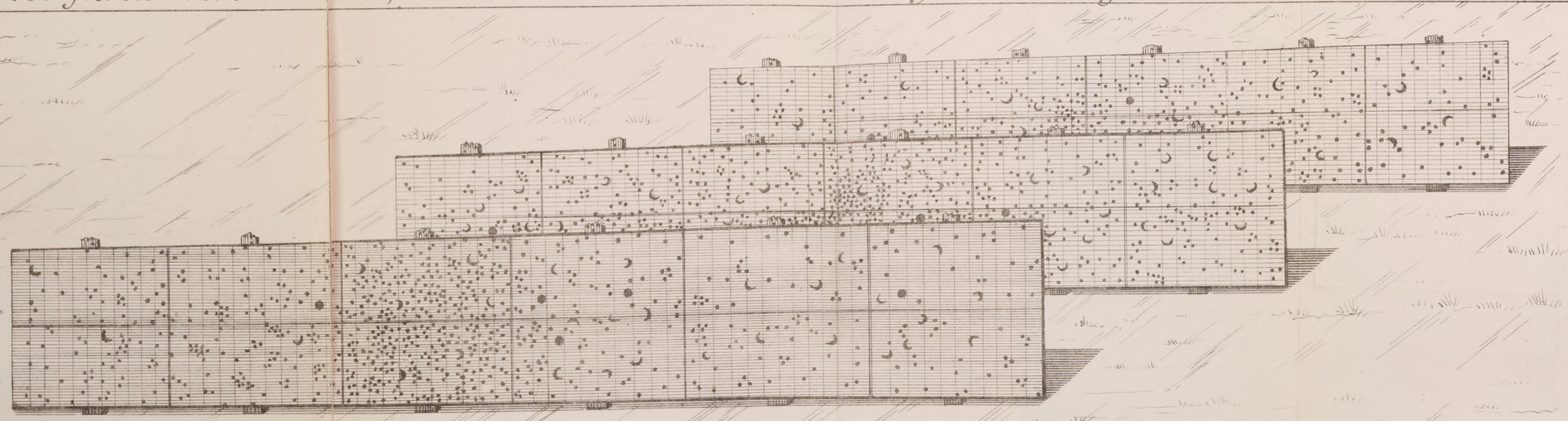
Representation of the three Screens which were fired at with Spherical Case Shot on the 29th of May 1805, when 2336 Shot, 74 Splinters of Shells, and 10 whole Shells were put through the three Targets, and the Ground contiguous furrowed with Grazes; the Screens were 50 yards from each other, and farthest Screen 700 yards from the Guns; dimensions of the Screens 54 feet long, & 9 feet high.



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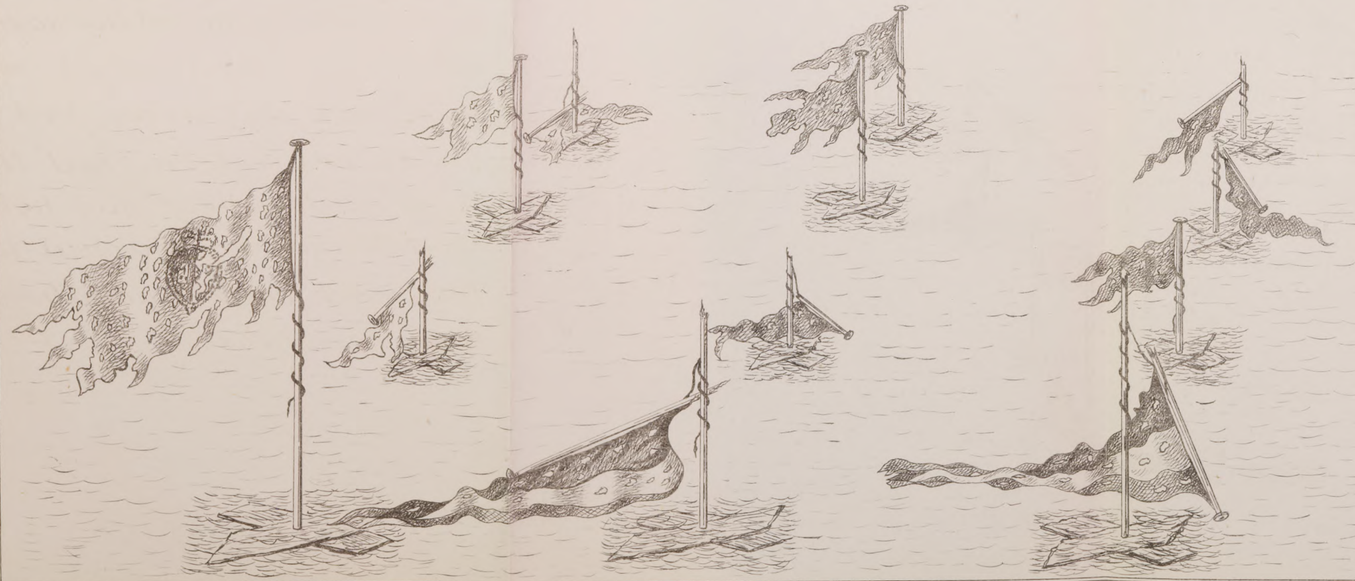
Representation of the twelve Flags before they were fired at with Spherical Case Shot on the 29th of May 1805. Distance of these Flags from the Guns 1350 yards.

These Flags were floated upon the River Thames by means of Deal Planks.

Representation of the same 12 Flags after they were fired at, when seven of them were shot away, and the remaining five Colors so torn that the Spanish Flag had ninety shot holes through it, these Flags were moored 15 yards distance from each other, and above $\frac{3}{4}$ of a mile from the Guns.



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THE DUTIES OF THE PERSONNEL OF A BATTERY OF FIELD ARTILLERY IN ACTION, FROM THE TIME IT TAKES UP A GIVEN POSITION UNTIL "CEASE FIRING" IS SOUNDED.

BY

LIEUT.-COLONEL W. KEMMIS, R.A.

"England expects that every man will do his duty."

The Silver Medal Prize Essay.

THE Arm Artillery, as a whole, or any particular branch of it—Field Artillery, for example—may be regarded as a powerful machine: one which, in its primary parts, is becoming, day by day, more developed, and therefore more perfectly adapted towards fulfilling its *rôle*.

In the application of any machine to the performance of work we well know that, to do its task efficiently and economically, not only must the machine itself be as complete and perfect as possible, but it must be applied with skill, the workman, or men, performing his, or their, particular part in the right way, at the right spot and at the right instant; and if this be not so, the advantages to be gained by the use of the machine cannot be realized. The same truth holds good in principle in the case of Field Artillery, though the results are incomparable in magnitude from the mightiness of the machinery of the latter, the multitude of its motors and the grave issues involved.

It is therefore a very pertinent enquiry, and particularly so at the present time, when a notable advance is being made in the power of Ordnance, "whether the personnel of Field (or other) Artillery, in itself, its organization, tactics and training, is fitted to utilize to the utmost degree possible that *matériel* with which its work is performed."

A very cursory glance at the records of our modern wars should satisfy any one inclined to be sceptical on the subject,—if there be such,—that our Officers and soldiers in the present day are no way inferior, in fighting and enduring qualities, to those, of whom it was said at the beginning of this century, that "they never knew when they were beaten;" and we may safely conclude that the raw material at our disposal is in itself as fitted as ever for conversion to the skilled gunner. True, the standard to which he must be brought, in order to meet

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modern requirements and to make proper use of the now more perfected *matériel*, is much higher than formerly; but, even so, if the man only possess the spirit and physique proper for a soldier, his being made to come up to that standard can be but a question of organization and training. The discussion of these subjects it is not our province to enter upon, in passing we may, however, be permitted to express a doubt as to whether the grave changes of recent years are conducive to obtaining in the personnel that high standard of proficiency, self-reliance, readiness to obey and to command, which might and therefore ought to be reached.[1]

The definite purpose for which guns in the Field are brought into action varies: it may be for the attack, or defence, of a position, or in forming part of an advanced or rear guard, or again, upon outpost duty; and according to the general circumstances prevailing, or, it may be, to the manner in which events of the moment fall out, the pieces may be brought into action deliberately and with more or less preparation, or, on the contrary, without opportunity for improving the position to be taken up, without much time for the exercise of judgment, and not unfrequently even upon the spur of the moment. But whatever the grand end in view may be, however events may influence the plan sketched out and the actual method employed, what though the minor tactics of a Battery must vary to meet particular circumstances, yet its *rôle* from the time of taking up a position for action until "cease firing" sounds may be said to be "to deliver its fire with maximum effect;" consequently the individual duties of the personnel must, in the main, stand constant, though circumstances may at one time add slightly thereto, or at another diminish a little therefrom. From this it follows, that our purpose will be served by setting out the duties of the personnel with respect only to what may be considered as a commonly prevailing state of affairs.

In order, partly, to the right grasping of our subject at the outset and to its proper completeness and, partly, to the absence of recognized rule on certain points, some notice of the dispositions, which lead up to the commencement of the duties of the personnel in action, seem called for.

It is always desirable, though not always possible, to select with deliberation the position which Artillery is to occupy for action. When this can be done and a definite spot has been assigned to a Battery Commander for his guns, he should have the opportunity of riding forward to examine the place, the bearing of the objective from it, &c., with a view to bringing his guns into it in the readiest manner and disposing them, when there, to the best advantage. This duty of examining the position, for the proper and effective application of the power in his hand, the Battery Commander should never delegate to another; in riding forward to examine it, he should be accompanied by

[1] We have a standing Committee to take cognizance of, and to advise those in authority upon, questions relating to Artillery *matériel*, with a view to improvement: Why should we not have a similar Committee to weigh all matters connected with the *personnel*, such as organization, training, &c.?

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one of his Staff N.-C. Officers[1] and by the Battery Range-takers:[2] these latter, however, need not be brought actually into the position but left, until required, as near to it as regard to exposure of purpose permits. The Staff N.-C. Officer is required with the Commander in order that, having been instructed as to the spot to be occupied by the guns and limbers in action, he may return, while the Commander remains occupied with the Range-takers, to the Second in Command with the information and with any special directions the Commander may think well to send respecting the road to the position,[3] halting anywhere previous to final movement into it, &c.; also, if the Second in Command has not already had instructions on the point, with regard to the intended post for the wagons and the best line for them to take to it;[4] having conveyed these, or such like, orders, the Staff N.-C. Officer may be useful in guiding the leading gun along the route, or afterwards a particular gun in taking up the exact position determined for it. Meanwhile the Commander, knowing exactly what he requires from his examination of the position, &c., and being for the moment free, gives instructions to the Range-takers and to the Officer commanding the escort of the Battery, if there is one, or, if he has to rely upon his own vedettes, he points out to them their individual posts and gives them their orders; he then rejoins his Battery either at the place where he directed its halt, or at latest before it comes into the position for action, so that this final movement may be under his own direction.

It is sometimes desirable, and possible, for the better protection of the gunners and guns, to dig pits: on such occasions, having been informed of the objective and the positions for the guns, the Nos. 1 of the detachments, checked by their Officers, should, each, first mark out the line of fire for his gun, then roughly trace the form of the pit and set the men to work.

We assume, then, the guns in the position, the limbers retiring to such place as may have been appointed for them; the ammunition wagons detached and moving to the spot they are to occupy; the forge, store and remaining wagons of the Battery on the line of march, in camp, or it may be at some previously arranged place, when the duties of the personnel in action commence, as follows:—

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[1] The senior, or Battery Sergeant-Major.

[2] Not by the Trumpeter. The Commander of the Battery escort, if there is one, should be at hand to receive his instructions so soon as the Battery Commander has made up his mind as to his dispositions. If there is no escort, and the Battery is not immediately supported by other troops, the Commander should take with him a few of his own spare men to post as vedettes for the proper safety of his guns in action.

[3] When it can be done previous to the guns taking up their final position, it is well for the Battery Commander to assemble, for a few minutes, his Officers and Nos. 1 and give them such insight into the object to be attained by the Battery fire and the tactics meant to be pursued, as may enable them to grasp the whole and so, afterwards, work their guns not only the more readily but the more intelligently.

[4] When the Battery is acting in conjunction with others, this, in the same manner as the position for the guns, would be determined by the Commander of the whole.

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The Battery Commander.

The Battery Commander must be considered as entirely responsible for his Battery at all times, following the orders of the Officer commanding the Troops, with which the Battery, if single, is acting, or those of the Divisional, or Corps, Artillery Commander, if it forms part of Divisional, or Corps, Artillery.

Under any circumstances then, that his responsibility be not curtailed, the actual working, or internal management, of the Battery for a particular end in view, should remain entirely in its Commander's hands, notwithstanding that he may, and at times must, be restricted by superior orders in acting upon his own judgment with regard to those points which lead up to the particular work required; thus, while the time, place and objective for the action of his Battery may, and must in the case of united action, be ordered for him, he should be left entirely untrammelled in the command of his guns in dealing with the objective.

As has already been stated, the great aim of a Battery in action may be said to be "to produce the maximum fire effect:" hence this must be the Commander's primary care and to insure it his first duty expressed in general terms.

We assume that before bringing his Battery into action, or, at latest, where lack of time forbids previous deliberation, on bringing it into action, the Commander has made up his mind as to the precise manner in which it will be best to deal with the objective, with regard to nature of ammunition, distribution of fire, &c.[1]

A Battery is composed of a certain number of guns, any one of which in action may be worked independently of and without regard to the others, yet the whole form a tactical unit of which the Commander is the head; consequently, and also because of his responsibility to which we have already alluded, he should be able to wield the whole as a single weapon, and apply the whole, as such, in that manner which for the moment is the most fitting: in short, he must, as a rule, have the fire of the Battery at all times in his absolute control. That he may attain this he must himself determine and order all those points which are common to the guns as a whole, not delegating them to the Officers and N.-C. Officers in immediate charge of their working, unless exceptionally under special circumstances.

Following this principle the Commander, having satisfied himself, so far as he may, of the general preparedness of the whole and having taken up that position himself from which he can best order the fire, observe its effect and take in the whole situation of affairs, commences the detail of his duties in action by giving the command to load,[2] specifying the nature of ammunition, the range,[3] or the elevation

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[1] These are questions of minor tactics, and therefore outside our present enquiry: for information respecting them, see *R. A. I. Prize Essay*, 1871, by Lieut. (now Major) H. W. L. Hime, R.A.

[2] In certain prepared positions he may, previous to this, find it possible and convenient to have a proportion of ammunition removed from the limbers and deposited in the gun pits.

[3] Ascertained already by the Range-takers. The Commander ought, however, to be a perfect judge of distance in case of failure of the Range-finder, or inability to use it.

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for the range, and the target,[1] at the same time naming, if necessary, any particular portion of the latter.

The guns are thus prepared to open fire, but before the Commander commits them, as a whole, to this, he has perhaps the most important point of his duty, with respect to fire effect, to attend to, namely, the checking and ascertaining with accuracy the range, or rather the elevation at which the guns require to be laid to obtain the required range. In doing this he is obliged to give the order "to fire" to the individual gun himself, as he may find it necessary, from observation of the round previous, to have the elevation altered from that which he first named.

Having satisfied himself as to the correct elevation, he directs the Battery to continue the fire at that elevation, giving at the same time the order of fire and that distribution of it, if any, over the objective, which he judges to be best.[2] Up to this common shell with percussion fuze, we may presume, has been employed: now the Commander is at liberty to change to shrapnel with time fuze should the objective so require to be dealt with; if he makes such change the next detail of his duty will be to determine the correct length of fuze,[3] a point of pretty well equal importance to that of ascertaining the proper elevation.

As the firing proceeds it is the Commander's duty to watch it carefully and the effect thereby produced,[4] noting and correcting any shortcomings either of the whole or, if it may be, of an individual gun: and, at the same time, making any change which would appear to be for the better in the ammunition or in the rapidity and distribution of the fire.

But, while thus engaged, the Commander must not be unmindful of, what may be termed, his secondary duty, that is to keep himself fully alert to the different phases of the fight, ever watching and ready to accommodate himself to them, in order that, so far as in him lies, he may secure every advantage offered and ward off, or mitigate, every evil threatened; in this view, he must, according as events of the moments rule to be for the best, order cessation of fire, change of target, fresh ranges to be taken, move the Battery from its position or, on the contrary, persistently keep up the fire and adhere to that position even it may be with the consequent loss of his guns. Should, however, these points not lie within the sphere of his ordering, by reason of the Battery acting with others under a common Commander other than himself, he yet requires to be equally alert in the respects enumerated, that he may intelligently and on the instant grasp and follow the orders of his superior or, should pressure of

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[1] This gives all that is necessary for loading and laying, except the deflection which, varying for each gun, the Commander cannot lay down.

[2] In distributing the fire it is necessary sometimes to alter the elevation of some of the guns should they have a nearer, or more distant, portion of the objective as their target.

[3] It is not necessary that this should be done previous to naming the order of fire.

[4] The superintendence of the "service" of the guns he must of necessity leave to those immediately in charge of them.

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circumstances so demand, act upon his own responsibility without such orders. It is not our province to discuss the proper course for the Commander to pursue under any of the possibilities cited;[1] but this much we may lay down, that whatever line is ordered for him, or, failing this, whatever course his own judgment approves, that it will be his duty persistently to adhere to.

In the exceptional case of being forced to sacrifice his guns, it becomes a detail of the Commander's duty to take any precautions, or steps, he may to save the gun-limbers, to stand to his gunners, guiding them and encouraging them by word and example to maintain their fire to the very last, and to see that his guns are in some manner rendered unserviceable and unremovable by the enemy on capture.

Another peculiar case deserves passing mention, namely, when a Battery has to cease firing from failure of ammunition, under which circumstances it is the Commander's duty to keep his guns still in position, on account of the bad moral effect it might produce did he retire, and to do what he can towards obtaining the needed supply.

As already stated, under certain circumstances[2] the Commander must break through the rule of retaining the Battery fire completely in his own control and must place it to some extent more in the hands of those immediately in charge of the guns by ordering "independent" fire; on such occasions his duties will remain as before detailed, and though he cannot so particularly observe and correct the fire, yet, on the other hand, there will be the greater need for watchfulness on his part as to the effect produced on the phases of the fight. So soon as the pressure which required independent fire is passed the Commander should revert to "successive," or order "cease firing," as the case may need.

Lastly, we must not omit that it is the duty of the Commander to inspire those under him with perfect confidence in himself and, under every circumstance, by his bearing, words and actions to yield them that moral support and encouragement which goes so far to assist them to surmount the greatest difficulties and to accomplish the grandest ends; with regard to his Second in Command it is his further duty to inform him, as fully as he may, of the end sought to be attained, the tactics he follows and the dispositions he makes.

The Second in Command.

The duty of the Second in Command, as well as of all subordinate Officers, in general terms, may be enunciated as follows: to support their Commander with their utmost of zeal, energy and intelligence, carrying out his orders, not merely in the letter but according to his known intentions, by example and word maintaining the discipline

[1] Such is a question of Tactics.

[2] For example, when very great rapidity of fire, and on the instant, is desired, as in the close defence or against a rapidly moving object.

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and steadiness and ensuring the proper performance of duty, of those under them.

The Second in Command, from the position he occupies in the Battery as such, as well as from his greater experience than the junior Officers, ought to have his particular duties so arranged as to give him a wider sphere for yielding general support to his Commander than given to the other Officers: again, in the event of the Commander becoming *hors de combat,* or being obliged to be temporarily absent from his Battery, he has to assume the command, and therefore should be fully conversant with the particular purpose in view in the action of the Battery, the mode in which it is proposed to attain it, &c., as we have before pointed out: hence he ought to have every facility possible for acquiring such information and for keeping himself up to all changes of circumstances as events progress; these premises furnish us with a general basis on which to frame his duties.

The ammunition wagons with the spare men and horses forming no inconsiderable portion of the Battery, being of the first importance for the due maintenance of the guns and having to be detached from, and to conform to the movements of the latter, must be in charge of an Officer; this care and the immediate superintendence of a certain number of guns are the duties which in action must devolve upon the Officers under the Commander. The question then arises, which is the most fitting to lay upon the Second in Command?

We reply, the care of the wagons with proper limitations: not because it can be said to be the more weighty duty of the two, for each during the battle has its time of chief importance and each in its place serves equally to the active efficiency of the Battery, but for the reason that when in charge of the wagons an Officer may be called upon to act to some extent independently of his Commander, which the senior ought to be the most qualified to do, and also that in that position the Second in Command may be, as it were, less tied down, and his sphere of action more in accordance with the basis we have already laid down.

Assuming, then, that the Second in Command is held responsible for the wagons, spare men and horses, having, in the absence of the Commander examining the position for the guns, detached these and directed them to their assigned place and having, by the return of the Commander, been relieved from the charge of the guns, he follows the wagons and, on their reaching their intended position, disposes them to the best advantage as regards cover, future movement, supply to the guns, &c., and takes any precaution against surprise which may appear to him desirable or for preserving their connection with the guns. His next care should be to assure himself of the position of the wagons which convey the reserve ammunition, if he is not already acquainted with it, or has any doubt upon the subject, and also to satisfy himself of the proper route to them.

It then follows for him to give the senior N.-C. Officer with the wagons any particular instructions which may be necessary for his guidance, having done which, with as little delay as possible, and being satisfied as to the security and well-being of the wagons he

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should return to the guns, there to yield such effectual assistance to the Battery Commander as he may. This can best be by it being arranged for him, in the first place, to attend to those matters which neither the Commander nor the subordinate Officers, from the nature of their respective work, can see to, and in the next to be left free to give his assistance wherever, for the moment, he sees that help and direction is needed and that he can yield it without taking upon himself the responsibilities or duties of others able to sustain them for themselves.

In this view it should be his duty to watch the expenditure of ammunition and the casualties in men and horses which occur, to order up what is necessary for replacement,[1] to see that it comes up in good time and that when it reaches the limbers it is properly utilized,[2] a duty which it is impossible that the Commander, engaged probably on a flank of the Battery in perfecting the fire, or the subordinate Officers, occupied between their guns with the service of the latter, can properly carry out.

While the Second in Command gives special attention to the replacement of ammunition, &c., he will of necessity see and should note the work going on at the guns: at the same time, he will have opportunity for communication with his Commander; hence he can yield assistance exactly at the spot and at the instant needed, and can see that the Commander's orders are understood and carried out: or, should events of the moment render any particular disposition desirable, without interruption of the firing, he can supervise it.

If a casualty occurs among the subordinate Officers, it will be the duty of the Second in Command, as when other casualties happen, to provide for the deficiency in the best manner he can: if two Officers remain this is simple enough, for he has merely to divide the charge of the guns between them, but if one only is left, with a charge already in his hands as great as he can effectually look after, what is to be done? Should the Second in Command take the place of the Officer *hors de combat* and tie himself down to perform the whole of that Officer's duties? We think not; rather should he be guided by circumstances, and redoubling his energy, give his best attention to the point of chief importance for the moment, preventing, meantime, any slackening in other points by a judicious use of the N.-C. Officers at his disposal.

On "cease firing" sounding, having obtained his instructions from the Commander, he should return to the wagons; or should the enemy

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[1] He should of course inform the Battery Commander, obtaining from him any special directions he may wish to give. To avoid mistakes the order may be written: a spare mounted man should be detached from the wagons to the limbers for the purpose of conveying such orders.

[2] The "*Field Artillery Exercise*," 1881, states, that the Major "is responsible that the guns in action are kept supplied with everything needful for their efficient working:" he is responsible, so far as he is responsible for everything in the Battery, but he cannot personally attend to it. The same book also lays down that "the Lieut.-Colonel or other Officer of less rank being in command of a section of Artillery when Batteries are massed, should direct the replacement of casualties:" but, as before, the Lieut.-Colonel will have enough on his hands without this, and having directed the position of the wagons, the replacement, as a matter of internal economy, should be left to the Battery Commander or such Officer under him as the duty lies with.

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reach the guns, leaving these to the Commander and other Officers to do the best they may, he should retire and endeavour to secure the wagons.

The Subordinate Officers.

These Officers we assume to be distributed equally throughout the Battery, each appointed to the immediate charge of a Half-Battery, or Division, according to their number. Their duty in action will then be, primarily, to carry out all the orders of the Commander and not to allow any deviation therefrom, lest the effect desired by him might not be produced or lest he should be misled in any particular by forming a judgment on grounds other than what he supposed; secondarily, to supplement those orders, by such additional directions in minor details, as may be necessary for their effectual carrying out.

To this end, dismounted, they must closely watch the service of their guns, particularly seeing that the ordered ammunition is properly supplied and prepared, the tangent-scale set to the named elevation, the due amount of deflection,[1] for any causes which exist to affect the true flight of the projectile, given and the guns correctly laid; they should also see that the guns are fired as ordered and, so far as they may be able, observe and form an opinion of the effect.[2] When it happens that independent firing is ordered they must exercise such control, subservient to any particular directions of their Commander, as they believe will conduce to the greater efficacy of the fire.

The Second in Command, as already stated, has to watch the expenditure of ammunition, casualties, &c.; nevertheless, it is the duty of the Subordinate Officers to take account themselves of this, and by notifying to the Second in Command what they require for the maintenance of the service of their guns ensure the supply they want; they should also report to him for the information of the Commander or to the Commander direct, if shorter to do so, anything exceptional which may occur in their charge, at the same time taking steps to put it right.

In the event of the enemy penetrating to the guns, the Subordinate Officers must see to the maintenance of the fire to the last, then to the guns being disabled and, remaining with their detachments, direct them in any way open for diminishing their danger or securing their safety.

Should it fall out that the Second in Command becomes *hors de combat*, it does not appear desirable that, in action, the senior Subordinate Officer should take up his special duties to the prejudice of his own, at the moment of first importance; such course might have a prejudicial effect, and it would seem better that the Staff N.-C. Officers,

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[1] The deflection being peculiar to each gun must of necessity be judged and determined in the first instance by the N.-C. Officer in charge of the individual gun, and not by the Officer who has supervision of more than one gun.

[2] After the range or length of fuze has been ascertained and ordered by the Commander, it may be that an Officer is convinced that a particular gun requires (as is quite possible) some slight alteration of elevation, &c., and, if he is so satisfied, he should bring it to the notice of his Commander and obtain his approval for the alteration.

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acting previously under the instructions of the Second in Command, should continue to the best of their ability to attend to the safety of the wagons and the supply of ammunition, under such instructions as they might receive either from the Commander or from the other Officers.

We have already adverted to the moral duties incumbent upon the Subordinate Officers in common with the Second in Command, and it is unnecessary to say more upon the subject.[1]

On "cease firing" sounding, the Divisional Officers, if the guns are not limbered up and moved off, should carefully examine their Divisions and report to the Commander.

The Staff Non-Commissioned Officers.

The limbers being separated from the guns, though but a short distance, and the Divisional Officers having in action their attention fully engrossed in an opposite direction, should, as a whole, be in charge of some responsible N.-C. Officer. For this duty the senior Staff N.-C. Officer is the most suitable, because he will thus have the greater scope for active usefulness, while he will be nearer to the Commander, who, failing an available Officer, might require to make special use of him: at the same time having in his daily routine of work much to do with the discipline and distribution of the Battery generally, and having thereby a perfect knowledge of the N.-C. Officers and men, he is well fitted to make the most of their individual abilities in emergency.

Being then in charge of the limbers, the senior Staff N.-C. Officer has first to retire them to the spot directed, placing them, if there be any choice, as advantageously as possible with regard to cover and convenience of movement for limbering up; he should then see that the gunners with the limbers are at once ready to supply ammunition and, so far as he may, that they supply it, as ordered, on the command to load; while the fighting proceeds he must maintain the limbers ready to move, carry out any special instructions which the Commander may give respecting them and see generally that the N.-C. Officers and gunners with them do their duty correctly: he should also note the expenditure of ammunition and the casualties which occur, reporting from time to time to the Second in Command, or, in his absence, to the Commander, obtaining his instructions and acting thereon.

When ammunition, spare men and horses arrive from the wagons, it will be his business, under the Second in Command, to see to the proper and ready distribution of the former and to the best utilization of the latter.

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[1] The Subaltern may be disposed to under-rate the duties required of him in action, considering that the Commander originates the orders governing the fire, and the Nos. 1 carry them out: he might, perhaps, do so were the Nos. 1 and gunners perfect and were the circumstances of battle set aside, but the former no more than the latter can be. In our opinion the Subaltern's duties are now more important than ever, when, by reason of "short" service, he has men less perfectly trained than formerly, and more wanting in essential self-reliance—men who are either comparatively young soldiers or half soldiers dug out from civil life.

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At the same time that the senior Staff N.-C. Officer fulfils the foregoing particular duties he will have opportunities for general usefulness, assisting the Officers when pressed in their work at the guns, engaged, perhaps, in one spot and unable to give attention at another equally requiring it; taking charge, mayhap, for the moment, of a gun at which the No. 1 has just fallen, keeping up its fire and restoring confidence to its gunners: particularly can his aid in this respect be valuable when the number of the Officers is reduced.[1]

Finally, it is the duty of the senior Staff N.-C. Officer—as it is of all other N.-C. Officers in their degree—to stand out as examples of obedience, endurance and every good quality[2].

It is necessary that a N.-C. Officer of experience remain with the wagons when detached from the guns, to act under the Second in Command with respect to them and to take charge of them in his absence: for this, the junior Staff N.-C. Officer is the most fitting, not merely because, as we have already pointed out, he is not the most suitable to be in charge of the limbers, but because the duties which he will there have with regard to supply will fit in well with that routine of work with respect to equipment usually given to him and, at the same time, he will be less liable to be placed *hors de combat*, which would cause many details in making good expenditure, accounting for deficiencies, &c., to fall upon the Commander after the action, when possibly the latter would have as much as he could do in reorganizing his Battery and in general superintendence of its re-fitting.

The first duty of the Second Staff N.-C. Officer will then be to assist the Second in Command in the dispositions which he may make with regard to the wagons, carefully noting what is done and the orders which he receives; guided by the latter his next duty will be to take every care of his charge in the absence of the Second in Command, maintaining it ready for any movement required, taking any additional precautions which, from time to time, may seem desirable and informing the Second in Command of anything of importance which may occur. It will further be his duty to send forward, as demanded, wagons, spare men and horses, to examine return wagons and to send, subject to any instructions he may have received, those which are empty to the reserve for further supply. If he finds any temporary repairs possible by the Battery artificers with him in the *matériel* sent back from the guns he should direct and superintend them.[3] While he performs the foregoing duties he must be careful to observe, as far as possible, the progress of the fight, and particularly any change in the position of the guns, or of the reserve ammunition wagons.

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[1] In such case the Sergt.-Major is sometimes detailed to look after the Division or Half-Battery of guns: it would, however, seem better to leave him mainly to the charge of the limbers and supply of ammunition, &c., his normal work.

[2] If the Sergt.-Major falls, the Senior Coverer should take charge of the limbers: his other duties in action must be carried through by the Captain alone.

[3] Any damaged *matériel* not so repairable, and yet desirable to keep, he should send with the wagons to the reserve: he should make a note in a memorandum book of what he sends to the latter and of what he receives therefrom.

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The Full Non-Commissioned Officers.

We suppose a Full N.-C. Officer in particular charge of each gun, under the Divisional Officer: his first business on the command "Action," having previously taken a survey of his surroundings, will be to unlimber his gun and place it as quickly as possible to the best advantage with respect to fire, cover, &c., and to assure himself that each man of the detachment is in his place and everything connected with the working of the gun ready; he should next take account of the force and direction of the wind, the difference of level of the gun wheels, if any, in order to determine the amount of allowance to make in setting the sights for such deflecting causes so soon as he receives the order to "load" and is informed of the objective; at the same time, he should note the position of the Commander and the Subordinate Officer, in order to know from what direction to expect his further orders and so to hear and grasp them at once. Thus being, with his detachment, completely ready for action, if any time still intervenes before he receives the command to "load," he may usefully employ it in more closely observing the ground all round and the enemy, and possibly, by the use of spade or pick, improve the spot on which the gun rests or the cover for the detachment.

It will be the N.-C. Officer's next duty to carry out the order to "load," not only performing to the best of his ability and energy the part which he then has to play, but seeing that each of those under him does so likewise, and thus that the due service of the gun is carried on, come what may, correctly and quickly. The detail which necessarily falls upon the N.-C. Officer in this is setting the sights, laying the piece and, if time-fuze is ordered, adjusting it to length, because these points are of first importance and require most care and skill, while they can conveniently be done by him: further, with regard to the fuze, if not adjusted by him, it would probably have to be prepared at the limber, where he could not supervise it, and a mistake might easily arise in passing the order for its length.

His gun being loaded and laid correctly, the N.-C. Officer is responsible that it is fired as ordered, when he should note the strike, or burst, of the projectile, that he may amend the deflection if it so requires, and also by his own observation assist the judgment of his Officers if called upon to do so;[1] after he maintains it in action to the best of his power until the command, or circumstances, compel him to cease firing.

Should his gun become disabled so that it cannot be fired, it will be his duty at once to take steps to bring it into action again or, if this is impossible, to place it in a condition for removal; again, should the enemy get amongst the guns, and no order for retiring have been given, having kept up his fire to the last moment possible, he should see to disabling the piece so that the enemy could neither use it nor remove it.

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[1] In rapid independent fire at close ranges it is impossible to do much in the way of observation, nor is much needed. The firing will then be in the N.-C. Officer's own control, and he can do anything, subject to his Officer's instructions, which he thinks will improve the effect.

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On "cease firing" sounding, the N.-C. Officer, if the guns are not limbered up and moved off, should carefully look round his charge, taking note of all damage, &c., amending anything that he may and report to his Officer.

The Pay Sergeant, as he may be one of the Full N.-C. Officers, here requires special mention; from the nature of his daily duties as Accountant and Clerk he must be a specially-selected and trained man, and therefore not easily replaced at any time, but particularly so when a successor has to be found in the field and on the instant, to take up the duties without warning, just as his predecessor happens to have left his documents and papers. Be as careful as he will in keeping and checking his accounts and returns, the Commander is pretty certain to be brought into difficulties by the sudden loss of his Pay Sergeant at that time when all his energies are required to maintain his Battery effective in personnel and matériel. The conclusion we would draw from this is that the Pay Sergeant should not be brought under fire, if he can reasonably be left out of it, and in this view he should be left either with the first or second line of wagons; if he be the junior Staff Sergeant, the former should be the case, but if not the latter, as being the more secure post, and at the same time a suitable one, because some N.-C. Officer of responsibility and not an artificer, should be in charge of the second line of wagons.[1]

The Rank and File Non-Commissioned Officers.

These N.-C. Officers should fill the posts next in importance to those sustained by the Full N.-C. Officers, while the senior amongst them should be available to take the place of the latter when required.

The general duties in action next in importance, after the charge of the individual guns, are the charge of the separate limbers and wagons, for of necessity there must be a particular N.-C. Officer responsible for each, though a Staff N.-C. Officer be over each group, as the latter cannot see to the details connected with each carriage nor look after it when temporarily away from the main body.

The senior Rank and File N.-C. Officer of each Sub-division should be the one placed in charge of the limber, that, as the one first to succeed the Full N.-C. Officer at the gun if he falls, he may be ready at hand to do so: to the next in seniority the care of the wagon should be given.

The first duty of each of these N.-C. Officers will be to carry out the orders given them by the Officers, or by the Staff N.-C. Officer, immediately over them and to look closely after their charges, particularly the drivers and the teams, they should see that every man under them performs his duty correctly, that any casualty or damage is put to rights, as far as it can be, without delay or confusion, so that the carriage and

[1] Uniting the duties of Qr.-Mr.-Sergeant and Pay Sergeant in the person of the former seems to us objectionable, and still more so having a Sergeant the No. 1 of a gun acting as Pay Sergeant: we believe the Service would be much benefitted by an additional Sergeant as Pay Clerk being allowed to each Battery.

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everything with it may be kept serviceable and ready to move on the instant.

When wagons are sent forward with a fresh supply of ammunition for the limbers, the senior of the N.-C. Officers with them takes charge of the whole, and on arrival at the limbers should report to the Staff N.-C. Officer of the latter what supply he has brought and receive from him any directions there may be to give respecting it. In shifting the ammunition, while the N.-C. Officer with each limber[1] should see that the limber boxes are carefully and properly packed, he with each wagon should superintend the removal of the ammunition from the latter and, having the spare gunners under his direction, be responsible that the shift is carried out orderly and quickly. On the duty being completed the senior N.-C. Officer of the wagons conducts them back to the remainder and on arrival reports to the Staff N.-C. Officer in charge. When empty wagons are sent to the reserve to be re-filled a similar method should be pursued.

Any Rank and File N.-C. Officers over and above those in charge of the limbers and wagons should be held in reserve with the latter ready to fill the places of those that fall.[2]

The Gunners.

The details of the duty of each man of the gun detachment must necessarily vary with the particular description of ordnance in use, as determined by practice and experience; the aim of each and every gunner will, notwithstanding, be the same, namely, with unflinching steadiness and ready obedience to carry out all points of his duty and by intelligence, precision and quickness, render the service and effect of his gun as perfect as possible.

One number of the detachment must remain at the limber, charged with the care, preparation, issue, &c., of ammunition: this man should be particularly reliable, self-reliant and conversant with the details of the ammunition, both in itself and its packing, he should therefore to a certain extent be selected for the post and should not be changed from it unless absolutely necessary.[3]

The duty of the spare gunners with the wagons will be simply to follow the instructions of the N.-C. Officer in charge, holding themselves at all times ready for work or for movement; if any are told off and posted as vedettes it will be their business to keep themselves on the alert, signalling and reporting accurately.

---

[1] The Coverer should never have to hold the No. 1's horse, the centre driver can always do so, thus leaving the Coverer more free: the lead driver can always hold the Officer's horse, the Coverer leading the horse to him on "action" and bringing the horse back on "limber up."

[2] It may sometimes be necessary to place a N.-C. Officer in charge of vedettes, if so he should be in direct communication with the Commander.

[3] The so-called "limber gunner" is the proper man for this duty, instead of being, as in our Service, a number at the gun (No. 4 - 9 or 16-pr.) because having the care of the carriage (under the N.-C. Officer in charge) he knows better than anyone where exactly to put his hand upon any article required, and is usually a man picked out for his good qualities: in the same manner the second limber gunner should not be at the gun (No. 5 - 9 or 16-pr.) but with the wagon, to take the principal part in the removal of ammunition from, and repacking ammunition in it, and also to replace the man at the gun-limber when required.

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The Drivers.

The duty of drivers in action, and we may include with them horse holders, is to follow implicitly the orders which they receive from their N.-C. Officers, keeping themselves and their horses steady and ever ready for any possible movement; they should carefully look round the horses, harness, &c., whenever they have an opportunity, caring for and easing the former in every way open to them, and reporting anything amiss.

In the event of any casualty happening in the team, it is the driver's duty to sit steady, maintaining his horses as quiet as possible, until he is directed to act in any particular manner by the N.-C. Officer in charge.

The Trumpeters.[1]

The first trumpeter—supposing that there are two to the Battery—has simply to attend the Battery Commander[2] and to obey exactly his directions.

The second trumpeter remaining with the wagons should follow the directions of the Officer or Staff N.-C. Officer in charge of them.

The Range-Takers.[3]

As already mentioned, preparatory to the Battery coming into position for action,[4] the Range-takers take such ranges as the Commander directs and inform him of the results without delay; having done so they should ascertain what further ranges he is likely to require and measure them together with the distances to all notable points, the knowledge of which might prove of assistance in firing at moving bodies: all these should be written down[5] for the Commander.

The Artificers.

In action with either the limber or wagons there is not much scope for the exercise of the special powers of a Farrier; a properly qualified Shoeing-smith can do anything that is likely to be needed, while it is undesirable to bring a highly trained man, who cannot easily be replaced, under fire, without commensurate gain. The proper place for the Farrier will therefore be in the second line with the forge wagon; this carriage[6] he should have charge of and, when he is so ordered, establish it for the purpose of doing such work as may be required.

---

[1] It seems to us a great mistake, and but poor economy, to have boys as trumpeters.

[2] Except when he leaves the main body of the Battery to select the position, &c.

[3] The importance of accurate range taking cannot be over estimated—surely then the "Range-taker" and his "assistant" in a Battery should stand distinct from the N.-C.-Officers and gunners, and be, not only specially selected and trained, but specially paid and horses particularly allowed for them. By "*Army Circular*," 1 Dec. 1882, provision is made for prizes for proficiency in signalling, and for extra duty pay to the N.-C.-Officer appointed to impart instruction therein for Garrison Artillery, Infantry and Cavalry: Why should not the same be applied to Range-takers of Field Artillery?

[4] Or, it may be, as the Battery comes into action.

[5] For this purpose, they should be supplied with convenient means, as for example, cards printed with lines radiating from a centre—when, the latter representing their position, the former would indicate the directions of the objects, which objects and the distances, respectively, to them they should write on the lines.

Under the N.-C. Officer in charge of the whole—the Pay Sergeant we before suggested.

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Of Shoeing-smiths we may assume four or five upon the establishment of the Battery: three of these should be with the first line, and the remainder in the second with the Farrier: of the former, one (mounted) should be, in action, with the limbers,[1] the other two with the wagons. The duty of the Smith with the limbers is to replace any shoes required, assist in putting right any damage and in clearing casualties in the teams, &c. The duty of the Smith with the wagons is similar.

Of Collar-makers, supposing that there are two, one should be with the ammunition wagon and the other with the limbers;[2] the duty of each is to make such repairs as are wanted in the harness and to yield such general assistance as he may.

Two Wheelers being upon the strength of the Battery, one should remain in the first line with the ammunition wagons, and the other in the second with the store wagon, the duty of the former would be to make such temporary repairs and adjustments of the carriages as may be needed and possible,[3] and of the latter to take charge of the store wagon, establishing it where and when directed.

It is hardly necessary to add that such specially trained men as Artificers should never be placed in the gun detachments so long as any other men are available to replace casualties; they should be reserved for that time and work for which they have been especially fitted and are required, and which, if not carried out when it ought to be, may very seriously hamper the efficiency of the Battery.

Conclusion.

Such is our estimate of the duties of the personnel of a Field Battery in action; however suitable and free from complexity any scheme of duties may seem, when thus viewed in the abstract, it must be far otherwise in its practical application, for then, the *rôle* of each man has to dovetail exactly into that of others and has to be sustained under, and adapted to, circumstances and surroundings of every character for the most part impossible to foresee and yet to be met on the instant.

Hence it is that, in educating and training the gunner up to his final purpose, namely, the producing in action with given matériel the maximum effect, it will not do to rest satisfied with mere formal instruction or carrying out certain fixed rules of procedure; the education, based upon whatever plan or organization approved, must, from first to last, have a practical bearing, each section or portion of it fitting in with the remainder, and all leading up to the ultimate end; everything brought into the course of education and training outside this must be superfluous and anything short of it must tend to shortcoming or failure.

---

1 He would here be convenient for moving with the guns: he should have a bag containing a few tools on one limber.

2 This Collarmaker should be mounted as the Shoeing-smith, in order to move readily to whatever Sub-division required his services, and to keep with the guns on their movement: he should have a bag with a few tools in it on one limber. An Acting Collarmaker should be with the second line of wagons, at the store wagon.

3 He should have a few tools, &c., in a bag, upon one of the wagons.

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A MOVING AND DISAPPEARING TARGET FOR RIFLE PRACTICE.

BY

MAJOR G. B. MACDONELL, R.A.

I WOULD feel some diffidence in submitting for publication in these "Proceedings" the description of the apparatus mentioned in the heading of this Paper, were it not that, in addition to the subjects congenial to their own profession, our Officers take a strong and wide interest in all that concerns the efficiency of the Army at large. Having this in mind, I venture to forward a description and working drawings[1] of a simple target that will, I hope, afford our brethren in the other branches of the Service an easy means of practising and perfecting their men in a part of the instruction in military rifle-shooting that hitherto has been practically neglected.

The plans of the system I advocate will place it within the reach of anyone to construct a working target for himself, and any description beyond a very brief one will be unnecessary.

A lever is mounted on an universal traversing pivot, so as to permit of motion to the right or left, and also of vertical movement. It is worked by a man in the marker's butt, who, by means of a counter-weighted T-headed hand-lever, can effect these motions with a minimum of exertion to himself.

At the end of the pivoted lever is bolted, or bent, an upright arm terminating in two sockets, into which the feet of the target-frame are fixed. The lever may either be of wood or iron.

The target is made of a light frame of iron rod, over which canvas has been stretched, and presents a surface of 2′ × 2′, or rather more than what would be shown by a man rising from behind the shelter of a parapet in order to fire a shot. A coloured paper representation of the above portion of a man (or, say, from the top of his cap to the elbows) should be pasted on to the canvas, in order to make the target

[1] I here with much pleasure acknowledge the assistance I have received from Lieut. Murray-Dunlop of my Battery in the preparation of the working detail.

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as natural and life-like as possible. The frame should have a central standard, terminating in two feet to fit the sockets on the top of the upright arm of the working lever, so that when much knocked about the target may be detached and replaced by another.

The normal position of the target is slightly below the crest of the parapet of the marker's butt, and consequently out of sight at the firing points, until it is raised and moved about by the marker pressing down and traversing the lever. He will thus readily be able to simulate the movements of a man partially covered by a parapet rising to fire, moving to right or left, disappearing and re-appearing at some other point. These movements may be varied almost *ad infinitum* by a clever marker.

The practice at a target such as has been described should be the finishing part of a soldier's course of rifle instruction, and should be looked forward to by him as the means of bringing into practical use all the elementary instruction he has been put through. It should only be carried on by men who at a range of 300 yards can make an almost perfect certainty of hitting a stationary target of the dimensions given above—the ability to do so would not be too much to ask from any marksman deserving the name.

I will not lay down any system of instruction beyond the few following hints below. I think that the course might be divided into three sections:—

First, I would recommend practice at the target rising and disappearing;

Second, at it in horizontal motion;

Third, at it, the marker being allowed to combine horizontal and vertical motions in manœuvring the target.

The time of exposure in any case should not exceed twenty or be less than ten seconds.

For the skirmishing practice with a section, or smaller body of men, the horizontal movements of the target may be dispensed with: the markers, sheltered by a long butt, would simply have to work a number of levers arranged like those in a railway signalman's box, and would give vertical movements to a number of dummies placed at the interval they would occupy were they men manning a parapet.

Finally, the men under instruction should be directed to advance by successive rushes, firing at the halts, and thus, in peace time, would have an opportunity of realizing and attempting to remedy *some* of the many disturbing influences they would have to contend against in actual warfare.

If the above or some similar or better system of rifle practice were adopted, and the instruction carried on throughout the year, instead of being massed into a short space of time as it now is, the shooting of the Army when brought to any *practical* test would be much improved. The men would acquire and keep up the habit of decision in the selection of a field object, of rapid and accurate aiming and firing, and

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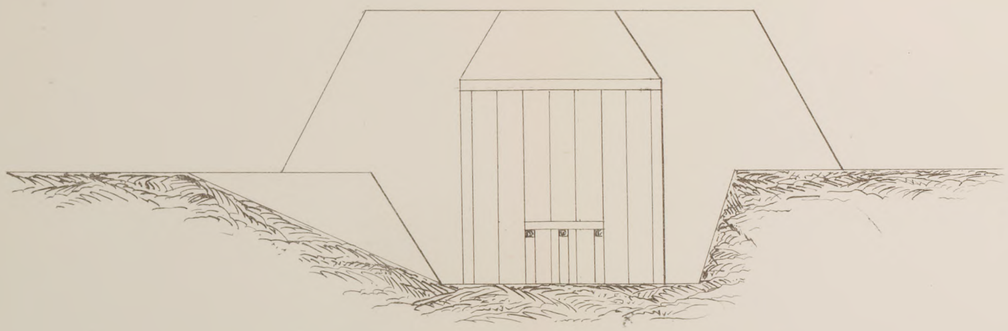
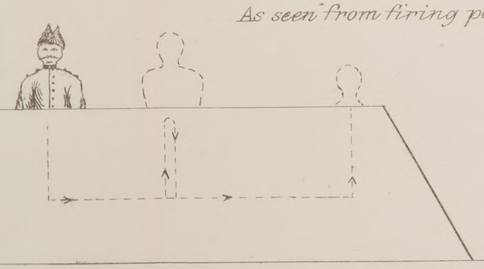
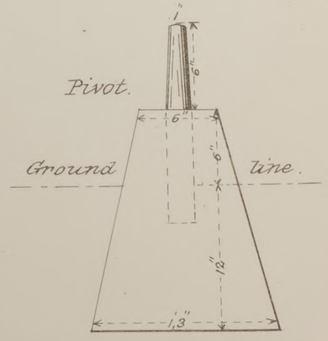
Section & Elevation on C.D.

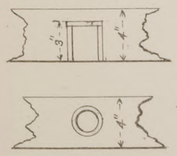


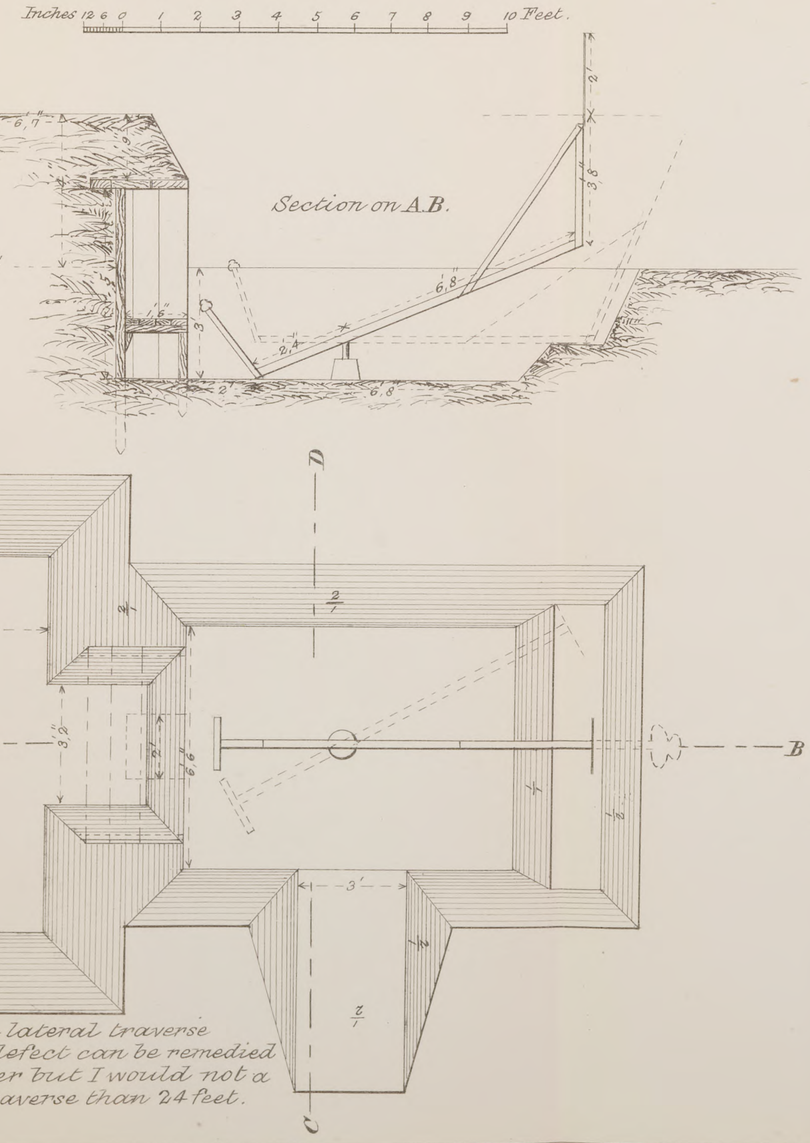
As seen from firing point.





Socket for pivot.





NOTE..It be objected that the lateral traverse is insufficient, this defect can be remedied by lengthening the lever but I would not a greater amount of traverse than 24 feet.

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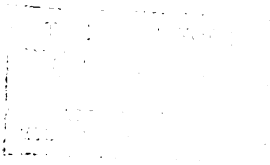

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of such confidence in their own powers as marksmen that the musketry fire of the British Infantry would regain the prestige it has lost of late years, and become in the wars to come as dreaded as it was in times now long gone by.

The target described was devised as a means of providing amusement for the men of the Battery now here—where amusement is difficult to obtain. While working out the practical detail it occurred to me that the principle might be useful in a wider sphere: hence this description.

ALEXANDRIA,
16 January, 1883.

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COMPARATIVE

OF

AUSTRIAN, ENGLISH, FRENCH, GERMAN,

COMPILED FROM VARIOUS SOURCES, AND

BY

MAJOR S. C.

Principal dimensions, &c.	AUSTRIAN.		ENGLISH.			FRENCH.	
	8cm	9cm	9-pr.	16-pr.	13-pr.M.L.	8cm	9cm
Calibre	2·95 ins.	3·43 ins.	3 ins.	3·6 ins.	3 ins.	3·15 ins.	3·54 ins.
No. of grooves	24	24	3	3	10	24	28
Depth of grooves ...	·049 in.	·049 in.	·11 in.	·11 in.	·05 in.	·019 in.	·023 in.
Length of bore from muzzle to end of chamber... ...	70·67 ins.	71·95 ins.	66 ins.	68·4 ins.	84 ins.	83·54 ins.	82·72 ins.
Ditto in calibres ...	24	21	22	19	·28	26½	22¼
Diameter of powder chamber... ...	3·11 ins.	3·58 ins.	...	...	3·15 ins.	3·27 ins.	3·7 ins.
Length of ditto ...	10·04 ins.	13·78 ins.	...	...	14·13 ins.	16·34 ins.	17·5 ins.
Pitch of rifling... ...	1 in 45 cals.	1 in 45 cals.	1 in 30 cals.	1 in 30 cals.	1 in 30 to 1 in 100.	1 in 120 to 1 in 25½	1 in 113 to 1 in 25½
Length of gun over all	76·77 ins.	81·17 ins.	74·5 ins.	78 ins.	92 ins.	89·76 ins.	89·76 ins.
Weight, including breech closing apparatus ..	658 lbs.	1071 lbs.	672 lbs.	1344 lbs.	960 lbs.	935 lbs.	1166 lbs.
Service charge of powder	2 lbs. 1 oz.	3 lbs. 5 ozs.	1 lb. 12 ozs.	3 lbs.	3 lbs. 2 ozs.	3 lbs. 5 ozs.	4 lbs. 3 ozs.
Ratio of ditto to weight of shell	1/5	1/4·2	1/5·2	1/5·4	1/4·3	1/3·7	1/4·2
Muzzle velocity ...	1385 feet	1470 feet	1391 feet	1350 feet	1595	1608 feet	1492 feet
Length of common shell	...	...	7·93 ins.	10 ins.	10·6 ins.	8·98 ins.	10·08 ins.
Weight of ditto filled, with fuze	...	...	9·1 lbs.	16·2 lbs.	13·4 lbs.	12·3 lbs.	17·6 lbs.
Weight of bursting charge	...	...	7·5 ozs.	18 ozs.	10 oz.	8·1 ozs.	9·5 ozs.
Length of double-skin ring shell	7·38 ins.	8·46 ins.	...	...	...	...	...
Weight of ditto filled, with fuze	9·5 lbs.	13·9 lbs.	...	...	...	...	...
Weight of bursting charge	4·4 ozs.	7·5 ozs.	...	...	...	...	...
Weight of shrapnel, with fuze ...	10·4 lbs.	15·6 lbs.	9·75 lbs.	17·9 lbs.	13·2 lbs.	12·5 lbs.	18 lbs.
No. of balls in ditto...	105	165	68	128	116	93	92
Weight of one ball ...	35 to the lb.	35 to the lb.	25 at 18, 38 at 34 to the lb.	72 at 18, 56 at 84 to the lb.	34 to lb.	23 to lb.	21 to the lb.

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TABLE

ITALIAN, AND RUSSIAN FIELD GUNS.

CORRECTED UP TO JANUARY, 1883.

PRATT, R.A.

	GERMAN.		ITALIAN.		RUSSIAN.		
9·5cm	8cm	9cm	7cm	9cm	4-pr. H.A.	4-pr. F.B.	9-pr.
3·7 ins.	3·09 ins.	3·46 ins.	2·95 ins.	3·43 ins.	3·43 ins.	3·43 ins.	4·19 ins.
28	24	24	12	24	24	24	24
·06 in.	·049 in.	·049 in.	·051 in.	·049 in.	·049 in.	·049 in.	·049 in.
89·17 in.	74·21 ins.	73·42 ins.	62·6 ins.	73·32 ins.	57·68 ins.	73·42 ins.	72·05 ins.
24	24	21	21	21½	17	21½	17⅕
4·13 ins.	3·62 ins.	3·94 ins.	3·11 ins.	...	3·86 ins.	3·86 ins.	4·63 ins.
11·82 in.	9·49 ins.	9·49 ins.	12·72 ins.	14·8 ins.	7·67 ins.	6·7 ins.	10·4 ins.
...	1 in 50 cals.	1 in 50 cals.	1 in 46⅔ cals.	1 in 45 cals.	1 in 36 cals.	1 in 40 cals.	1 in 36 cals.
98·4 in.	82·67 ins.	82·67 ins.	69·5 ins.	82·67 ins.	66·9 ins.	82·6 in.	82·6 ins.
1553 lbs.	858 lbs.	990 lbs.	650 lbs.	1071 lbs.	802 lbs.	1006 lbs.	1370 lbs.
4 lbs. 10 oz.	2 lbs. 12 ozs.	3 lbs. 5 ozs.	1 lb. 14 ozs.	3 lbs. 3 ozs.	3 lbs.	3 lbs.	4 lbs. 1 oz.
$\frac{1}{5}$	$\frac{1}{4}$	$\frac{1}{4·7}$	$\frac{1}{5}$	$\frac{1}{4·7}$	$\frac{1}{5}$	$\frac{1}{5}$	$\frac{1}{6·8}$
1453 feet	1525 feet	1456 feet	1381 feet	1490 feet	1350 feet	1452 feet	1225 feet
11·7 in.	...	...	...	...	...	...	...
23·9 lbs.	...	...	...	...	...	...	...
12·8 oz.	...	...	...	...	...	...	...
...	7·87 ins.	8·86 ins.	7·36 ins.	8·86 ins.	8·9 ins.	8·9 ins.	11·09 ins.
...	11·2 lbs.	15·4 lbs.	9·35 lbs.	14·8 lbs.	15·1 lbs.	15·1 lbs.	27·5 lbs.
...	7·8 ozs.	9·5 ozs.	6 ozs.	7 ozs.	7·1 oz.	7·1 ozs.	14·4 oz.
24 lbs.	12·2 lbs.	17·9 lbs.	9·24 lbs.	14·7 lbs.	15·1 lbs.	15·1 lbs.	27·5 lbs.
104	123	210	100	177	165	165	340
...	27 to the lb.	27 to the lb.	28 to the lb.	28 to the lb.	41 to the lb.	41 to the lb.	41 to the lb.

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COMPARATIVE TABLE—(*continued*).

Principal dimensions, &c.	AUSTRIAN.		ENGLISH.			FRENCH.	
	8cm	9cm	9-pr.	16-pr.	13-pr. M.L.	8cm	9cm
Weight of bursting charge	1·6 oz.	3 ozs.	·75 oz.	1·5 oz.	·75 oz.	5 ozs.	7 ozs.
Weight of case shot...	10·4 lbs.	16·48 lbs.	9·75 lbs.	15·2 lbs.	13·5 lbs.	12·3 lbs.	17·3 lbs.
No. of balls in ditto...	72 hard lead	120 hard lead	110 hard lead	176 hard lead	340	85 hard lead	123 hard lead
Weight of one ball ...	10 to the lb.	10 to the lb.	16½ to the lb.	16½ to the lb.	34 to lb.	10⅓ to the lb.	10⅓ to the lb.
GUN-CARRIAGES.							
Weight of gun-carriage equipped with gun ...	1685 lbs.	2283 lbs.	2140 lbs.	2930 lbs.	2240 lbs.	2101 lbs.	2662 lbs.
Diameter of wheel ...	54 ins.	54 ins.	60 ins.	60 ins.	60 ins.	56½ ins.	58½ ins.
Track	60¼ ins.	60¼ ins.	62 ins.	62 ins.	62 ins.	56½ ins.	60 ins.
Rounds carried on gun	...	...	4 case	4 case	2 case	...	...
LIMBERS.							
Diameter of wheel ...	54 ins.	54 ins.	60 ins.	60 ins.	60 ins.	56½ ins.	58½ ins.
Weight of limber, packed	1730 lbs.	1940 lbs.	1796 lbs.	1835 lbs.	1988 lbs.	1397 lbs.	1738 lbs.
Rounds carried in limber—							
Common shell ...	...	...	8	6	8	14	15
Double-skin ring shell	24	20	...	...	...	...	...
Shrapnel ditto ...	12	10	28	18	26	13	10
Case	4	4	...	...	2	2	1
Total	40	34	36	24	36	29	26
Weight, complete, behind team ...	3415 lbs.	4223 lbs.	3936 lbs.	4769 lbs.	4228 lbs.	3498 lbs.	4400 lbs.
Number of horses ...	6	6	6	8	6	6	6
Weight per horse without gunners	570 lbs.	704 lbs.	656 lbs.	596 lbs.	705 lbs.	583 lbs.	733 lbs.
Number of guns in a Battery ...	8*	8	6	6	6	6	6
Number of wagons ...	8	8	6	6	6	9	9
Weight of ditto (with limber) ...	4287 lbs.	4728 lbs.	4578 lbs.	4578 lbs.	5012 lbs.	4048 lbs.	5038 lbs.
Number of horses ...	6	6	6	6	6	6	6
Weight per horse ...	713 lb.	788 lbs.	763 lbs.	763 lbs.	835 lbs.	675 lbs.	840 lbs.
Number of rounds in wagon—							
Common shell ...	...	...	24	18	22	45	40
Double-skin ring shell	78	65	...	...	...	...	...
Shrapnel ditto ...	24	20	84	54	82	42	35
Incendiary shell ...	6	5	...	...	...	...	...
Case	4	4	...	...	2	...	1
Total carried in wagon	112	94	108	72	106	87	76
Total number of rounds per gun carried by the Battery	152	128	148	100	142	160	138

* 6 only in Horse Artillery.

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	GERMAN.		ITALIAN.		RUSSIAN.		
9·5cm	8cm	9cm	7cm	9cm	4-pr. H.A.	4-pr. F.B.	9-pr.
5 oz.	·66 oz.	·8 oz.	·46 ozs.	·6 oz.	2·1 ozs.	2·1 ozs.	4 ozs.
24 lbs.	11 lbs.	16·5 lbs.	9 lbs.	15·7 lbs.	14·9 lbs.	14·9 lbs.	27 lbs.
186 hard lead	76 zinc	76 zinc	126 zinc	226 hard lead	102 zinc	102 zinc	171 zinc
$10\frac{1}{3}$ to lb.	10 to the lb.	6 to the lb.	20 to the lb.	20 to the lb.	$7\frac{1}{2}$ to the lb.	$7\frac{1}{2}$ to the lb.	$7\frac{1}{2}$ to the lb.
3190 lbs.	1968 lbs.	2168 lbs.	1531 lbs.	2468 lbs.	1802 lbs.	2114 lbs.	2644 lbs.
$58\frac{1}{2}$ ins.	55 ins.	55 ins.	50 ins.	$58\frac{1}{4}$ ins.	55 ins.	55 ins.	55 ins.
60 ins.	60 ins.	60 ins.	53 ins.	$60\frac{1}{4}$ ins.	65 ins.	66 ins.	65 ins.
...	1 case	1 case	2 case	2 case.	2 case.	2 case.	1 case
$58\frac{1}{2}$ ins.	55 ins.	55 ins.	50 ins.	$58\frac{1}{4}$ ins.	55 ins.	55 ins.	55 ins.
1848 lbs.	2000 lbs.	2100 lbs.	1275 lbs.	1800 lbs.	1982 lbs.	1982 lbs.	1982 lbs.
10	...	...	...	...	...	...	...
...	24	20	20	16	12	13	7
6	12	10	18	17	15	15	9
2	2	2	2	1	3	2	2
18	38	32	40	34	30	30	18
5038 lbs.	3968 lbs.	4268 lbs.	2806 lbs.	4268 lbs.	3784 lbs.	4096 lbs.	4626 lbs.
6	6	6	4	6	6	6	6
829 lbs.	660 lbs.	711 lbs.	701 lbs.	711 lbs.	635 lbs.	682 lbs.	770 lbs.
6	6	6	8*	8	6	8	8
9	8	8	8	8	9	12	16
5258 lbs.	4144 lbs.	4655 lbs.	2998 lbs.	4686 lbs.	4721 lbs.	4721 lbs.	4719 lbs.
6	6	6	4	6	6	6	6
876 lbs.	690 lbs.	776 lbs.	750 lbs.	741 lbs.	787 lbs.	787 lbs.	787 lbs.
48	...	...	...	...	...	...	...
...	60	55	50	48	42	43	25
24	24	20	48	47	45	45	27
...	...	...	...	...	...	...	...
...	2	2	2	1	3	2	2
72	86	77	100	96	90	90	54
128	154	136	140	130	165	165	126

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EXPERIMENTS WITH SMALL SHOT.

BY

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THE following account of Experiments, made with the object of determining the velocity of small shot, may prove of interest to Officers who are fond of shooting, and it is therefore submitted for publication.

These experiments were made in order to test the accuracy of various statements as to the strength of Schultze powder (sawdust powder) and E. C. powder (granulated guncotton), which have lately appeared in letters in *The Field*, and also because very little seemed to be known about the velocity of shot when black gunpowder formed the charge.

The Boulengé chronograph was the instrument used for obtaining the observed velocities, and the muzzle and remaining velocities were calculated with the aid of Professor Bashforth's tables.

The Boulengé chronograph is so well known an instrument that any description of it is unnecessary, and it need only be stated that, during the trials, a wire screen and a single wire across the muzzle of the gun were used in conjunction with the instrument, and that the screen was placed at a distance of 60 feet in front of the muzzle.

Having ascertained the observed velocity, *i.e.*, the mean velocity at a point 30 feet from the muzzle (half way between the muzzle and screen), Bashforth's tables enable us to calculate the muzzle velocity, and also the remaining velocity and time of flight, for any point in the trajectory of the shot, and Tables I., II., and III., hereafter given, show the results of these calculations for Nos. 5, 6, and 8 shot, starting with the highest and lowest muzzle velocities which are likely to be met with when using the ordinary charges for a 12-bore gun.[1]

When Bashforth's tables are used for calculating the remaining velocity or time of flight of a projectile, it is necessary to know the weight of the projectile and its diameter: but as in a charge of small shot both the weights and diameters of the pellets vary in amount, one is obliged to take the mean weight and diameter of a large number of pellets, and to consider that calculations based on these mean weights and diameters are fairly correct for the entire charge.

[1] The gun which is sold as a 12-bore, has 13 stamped on the barrels at the breech.

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All the experiments carried out were with the three sizes of shot commonly used in this country for game shooting, viz., Nos. 5, 6, and 8, and perhaps it may be interesting to the reader to see how the diameters of the pellets varied in each size.

In order to arrive at the mean diameters, twenty pellets of each size of shot were accurately measured with the following results:—

Pellets.	No. 5 shot.	No. 6 shot.	No. 8 shot.
1	0·109-inch.	0·097-inch.	0·085-inch.
2	0·105 "	0·099 "	0·092 "
3	0·110 "	0·100 "	0·0925 "
4	0·106 "	0·104 "	0·0915 "
5	0·108 "	0·102 "	0·088 "
6	0·110 "	0·0955 "	0·090 "
7	0·1095 "	0·1015 "	0·091 "
8	0·1085 "	0·096 "	0·0905 "
9	0·110 "	0·1025 "	0·085 "
10	0·109 "	0·100 "	0·089 "
11	0·114 "	0·106 "	0·087 "
12	0·100 "	0·090 "	0·081 "
13	0·107 "	0·0995 "	0·090 "
14	0·107 "	0·1045 "	0·084 "
15	0·1115 "	0·102 "	0·088 "
16	0·109 "	0·1065 "	0·093 "
17	0·111 "	0·1035 "	0·090 "
18	0·1075 "	0·098 "	0·086 "
19	0·111 "	0·098 "	0·084 "
20	0·107 "	0·1015 "	0·087 "
	20) 2·1700 "	20) 2·0160 "	20) 1·7645 "
Mean diameters	0·1085 "	0·1008 "	0·088225

Having taken these measurements as the mean diameters for each size of shot, the mean weights of the pellets were got by weighing one hundred of them and dividing the total weight by 100.

	No. 5.	No. 6	No. 8.
Weight of 100 pellets	197 grains	152 grains	103 grains
Weight of 1 pellet	1·97 "	1·52 "	1·03 "

Taking these weights and measurements, the following was found to be the value of $\frac{d^2}{w}$ for each size.

	No. 5.	No. 6.	No. 8.
Value of $\frac{d^2}{w}$	41·831	46·792	52·899

All the cartridges used were bought from the same tradesman, who obtained them direct from the factory where they were filled; and although the method of loading was identical in all, and the powder (in those charged with gunpowder) was supposed not to vary in quality, it will be seen that no two boxes gave similar results.

The first experiments were made with cartridges filled to order, and were supposed to contain the usual charge of 3 drs. of powder and 1⅛ oz. shot; but as the velocities obtained were very irregular, a number of the charges from each box were carefully weighed, when it

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was found that almost invariably the amount of powder was deficient, and the weight of shot was generally in excess.

It may be well to give the weights of powder and shot found in the cartridges which were examined, remembering that 3 drs.=82 grains, and $1\frac{1}{8}$ oz.=492 grains.

Five cartridges were taken out of each box of ammunition, and the powder and shot in each cartridge carefully weighed, with the following result:—

Charge supposed to be 3 drs. of powder and $1\frac{1}{8}$ oz. of No. 5 shot.

Cartridges.	Box No. 1.		Box No. 2.	
	Powder.	Shot.	Powder.	Shot.
	Grains.	Grains.	Grains.	Grains.
1	79	481	82	502
2	73	484	82	522
3	78	479	81	510
4	78	470	83	515
5	77	478	80	501
Mean weight	77	478·4	81·6	510
Supposed charge	82	492	82	492
Difference	−5	−13·6	−0·4	+18

Supposed charge, 3 drs. powder, and $1\frac{1}{8}$ oz. No. 6 shot.

Cartridges.	Box No. 3.		Box No. 4.	
	Powder.	Shot.	Powder.	Shot.
	Grains.	Grains.	Grains.	Grains.
1	80	533	75	545
2	78	537	75	539
3	79	535	75	540
4	82	530	75	542
5	81	527	74	556
Mean weight	80	532·4	74·8	544·4
Supposed charge	82	492	82	492
Difference	−2	+10·4	−7·2	+52·4

Supposed charge, 3 drs. powder, and $1\frac{1}{8}$ oz. No. 8 shot.

Cartridges.	Box No. 5.		Box No. 6.	
	Powder.	Shot.	Powder.	Shot.
	Grains.	Grains.	Grains.	Grains.
1	80	514	80	508
2	78	507	82	512
3	80	507	81	511
4	79	507	82	513
5	80	505	81	516
Mean weight	79·4	508	81·2	512
Supposed charge	82	492	82	492
Difference	−2·6	+16	−0·8	+20

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Having found the charges of cartridges, which were filled to order, vary so considerably, the later experiments were made with cartridges having the powder and shot carefully weighed.

It will be seen on examining the weights of powder and shot contained in these sample cartridges taken from each box, that although the charges were supposed to be identical as to weight, the average weights of no two samples are the same, and, indeed, no two cartridges out of the whole thirty contain precisely the same charge.

Now, supposing that powder of the same quality and strength had been used in loading all the cartridges, it is clear that the muzzle velocities cannot fail to be affected by such irregularity in weights.

We have supposed that the powder was the same in all samples; but when examined, it was found to differ in appearance and size of grain, and when some cartridges from each box were stripped and carefully reloaded with correctly weighed charges, the muzzle velocities obtained with them showed that the powder varied very much in strength.

The unweighed and the weighed charges, when fired from the same gun, gave the following average muzzle velocities :—

Boxes.	Muzzle Velocity.	
	Unweighed Charges.	Weighed Charges.
1	1091 f. s.	1082 f. s.
2	1314 "	1278 "
3	1048 "	1075 "
4	1073 "	1180 "
5	1316 "	1323 "
6	1317 "	1352 "

The whole of the cartridges used were supposed to be loaded with the best sporting powder; and if the velocity given by this class of powder varies so greatly, it must fall off considerably when the powder is of inferior quality.

The mean velocity obtained with *unweighed* charges should not be considered as a proof of the quality of the cartridges, because one or two rounds which have a heavy powder, or light shot charge, may unduly raise the average.

As several samples of ammunition were made use of during the trials, it will make matters plainer to give a detailed list of all, and

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when we have to mention any of them later on, to designate each by its distinguishing *letter*, as given in the following table :—

Samples.	No. of shot.	Unweighed charges. Mean weight of 5 rounds.		Cartridges filled with weighed charges.		Average muzzle velocity when fired from the same barrel. (right barrel of No. 2 gun.)	Remarks.
		Gun-powder.	Shot.	Gun-powder.	Shot.		
		grains.	grains.	grains.	grains.	feet. per sec.	
A	5	77	478·4	—	—	1091	
B	"	—	—	82	492	1082	"A" cartridges reloaded.
C	"	81·6	510	—	—	1314	
D	"	—	—	82	492	1278	"C" cartridges reloaded.
E	6	80	532·4	—	—	1049	
F	"	—	—	82	492	1075	"E" cartridges reloaded.
G	"	74·8	544·4	—	—	1073	
H	"	—	—	82	492	1180	"G" cartridges reloaded.
K	"	—	—	82	492	1294	
L	"	—	—	82	448	1336	
M	8	79·4	508	—	—	1317	
N	"	—	—	82	492	1323	"M" cartridges reloaded.
N′	"	—	—	82	437·5*	1380	"
		Schultze powder.		Schultze powder.			
O	5	42	507	—	—	1308	
P	6	—	—	45	492	1320	Made up for experiment.
Q	"	—	—	47	492	1339	"
		E. C. powder.		E. C. powder.			
R	6	—	—	45	492	1228	"
S	"	—	—	47	492	1340	"
T	"	—	—	45	492	1363	"

* 82 grains=3 drams. | 437·5 grains=1 oz. | 492 grains=1⅛ oz.

The cartridge cases used were the ordinary paper cases, except when the charges were of Schultze, or E. C. powder, when the "Bailey patent gas tight" cases were substituted, and were found to entirely prevent any escape of gas. The "Field wadding" was used throughout the experiments.

Besides testing the muzzle velocity which different samples of ammunition would give when fired from the same gun barrel, an attempt was made to discover how the velocity would be affected when the same sample of cartridges was fired from different guns, or from the right and left barrels of the same gun.

A list of the guns is given, with a distinguishing number for each, in case we may have to refer to any one of them again.

No.	Nature of Barrel.		No.	Nature of Barrel.	
	Right.	Left.		Right.	Left.
1	Cylindrical.	Cylindrical.	7	Cylindrical.	Modified choke.
2	"	"	8	"	Full choke.
3	"	"	9	"	"
4	"	"	10	Modified choke.	Modified choke.
5	"	Full choke.	11	Cylindrical.	Cylindrical.
6	Modified choke.	"	12	"	"

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Some of these guns were of Birmingham make, and others were by well-known London makers; the barrels of all being 30 in. in length, except No. 1 gun, which had 28-in. barrels.

In order to show how the velocities given by similar cartridges varied, those obtained from five consecutive rounds of each sample of ammunition are recorded. The cartridges were all fired from the right barrel of No. 2 gun.

Rounds.	Samples of Ammunition.					
	A.	B.	C.	D.	E.	F.
	f. s.	f. s.	f. s.	f. s.	f. s.	f. s.
1	1097	1067	1335	1291	1042	1058
2	1101	1083	1310	1263	1034	1082
3	1063	1086	1307	1263	1073	1087
4	1094	1094	1289	1284	1040	1093
5	1101	1080	1329	1289	1054	1057
Mean muzzle velocity.....	1091·2	1082	1314	1278	1048·6	1075·4

Rounds.	Samples of Ammunition.						
	G.	H.	K.	L.	M.	N.	N.′
	f. s.	f. s.	f. s.	f. s.	f. s.	f. s.	f. s.
1	1105	1192	1305	1338	1329	1322	1399
2	1079	1181	1288	1338	1315	1301	1299
3	1097	1123	1312	1325	1306	1343	1375
4	1031	1241	1312	1356	1295	1325	1347
5	1054	1163	1251	1325	1338	—	—
Mean muzzle velocity....	1073·2	1180	1293·6	1336·4	1316·6	1322·7	1380

Rounds.	Samples of Ammunition.					
	O. Schultze powder.	P. Schultze powder.	Q. Schultze powder.	R. E. C. powder.	S. E. C. powder.	T. E. C. powder.
	f. s.	f. s.	f. s.	f. s.	f. s.	f. s.
1	1313	1273	1341	1235	1323	1415
2	1133*	1338	1337	1227	1370	1276
3	1302	1323	1325	1222	1308	1368
4	—	1356	1358	1222	1376	1368
5	—	1312	1335	1235	1325	1390
Mean muzzle velocity.....	1307·5	1320·4	1339·2	1228·2	1340·4	1363·4

* This round was not included in the average.

With the above results before us, we cannot fail to notice how greatly the velocity varies in only five rounds, both with the measured and the weighed charges, but even with carefully made up rifle ammunition a difference of about 20 ft. per second is usually found between the highest and lowest velocities.

In the case of small shot a source of error exists which is not present when taking the velocities of bullets, viz., that the quickest pellets of the charge need not always cut the wires of the screen, but may pass

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between them; the chronograph only showing that the wires were severed by some portion of the charge.

It would perhaps have been more satisfactory had a larger number of rounds been fired in order to obtain the average velocity; but if we accept the above mean velocities as approximately correct, we must allow that the power of sporting cartridges lies between very wide limits. There is no reason to suppose that inferior powder was used in loading any of the cartridges tried—indeed, the probability is that all of it was considered good powder; so we can only imagine how great would be the loss in velocity when damaged or bad powder is put into the cartridges. Do we never buy cartridges which are made up with damaged powder?

The experiments made with Schultze and E. C. powder have been so few in number that it would be premature to form any decided opinion respecting them at present.

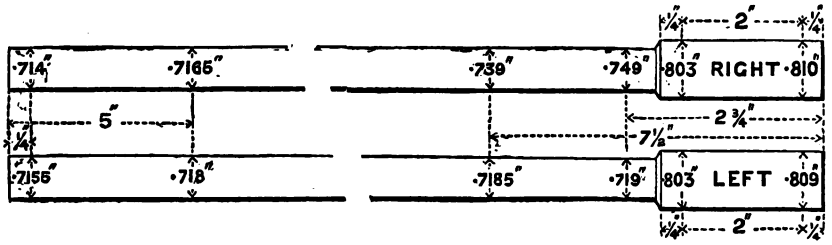
These explosives no doubt possess great strength (sometimes too great), make little smoke, and cause slight fouling in the barrels, but at present the velocities they give are not very regular.

We now come to the trials made with the object of determining how the boring of the gun barrels affects the muzzle velocity. As no sufficiently accurate appliance was available with which to measure the whole of the bore of each barrel, all that could be done was to make sulphur casts of the muzzle and breech ends (in two cases casts of the whole bore were taken). These casts were carefully measured, and the results of the measurements will be given when we deal with each gun in turn.

It will be seen that the term "cylindrical," as applied to these gun barrels, is not mathematically a true one, all the so-called cylindrical barrels which were examined being anything but true cylinders.

Having already seen how the velocities of five consecutive rounds vary, it will be unnecessary to have the result obtained with each round recorded, but merely to note the mean muzzle velocity obtained from five rounds fired from each barrel.

No. 1 GUN.—Cylindrical barrels.



		Cartridges.			
		A.	E.	M.	N.
		f. s.	f. s.	f. s.	f. s.
Mean muzzle velocities	Right barrel	1035·4	1008·4	1260·8	1281
	Left barrel	1098·6	1069	1317·8	1355

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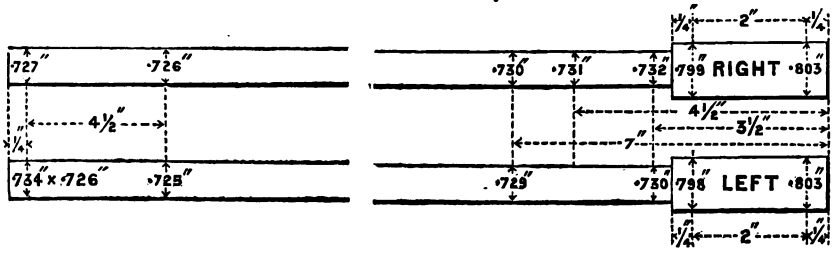
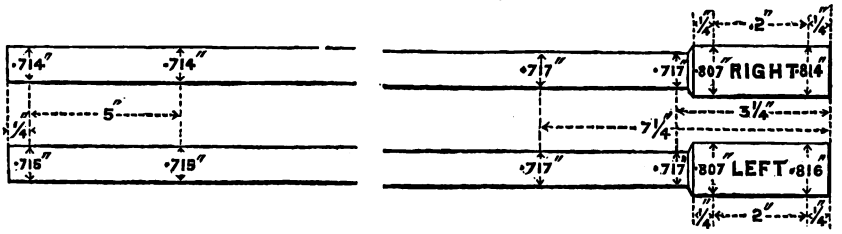
No. 2 GUN.—Both barrels cylindrical.



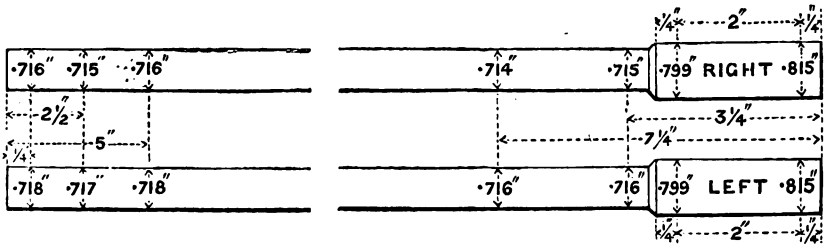
		Cartridges.					
		A.	B.	E.	H.	M.	N.
		f. s.	f. s.	f. s.	f. s.	f. s.	f. s.
Mean muzzle velocities	Right barrel	1091·2	1082	1048·6	1180	1316·6	1351·8
	Left barrel	1087	1067·6	1045·2	1177·8	1335	1359·4

No. 3 GUN.—Both barrels cylindrical.



		Cartridges.	
		H.	N.
		f. s.	f. s.
Mean muzz'le velocities	Right barrel	1171·6	1349·6
	Left barrel	1163·4	1341·3

No. 4 GUN.—Both barrels cylindrical.



		Cartridges.	
		H.	N.
		f. s.	f. s.
Mean muzzle velocities	Right barrel.	1195·8	1363·6
	Left barrel	1182·8	1352·3

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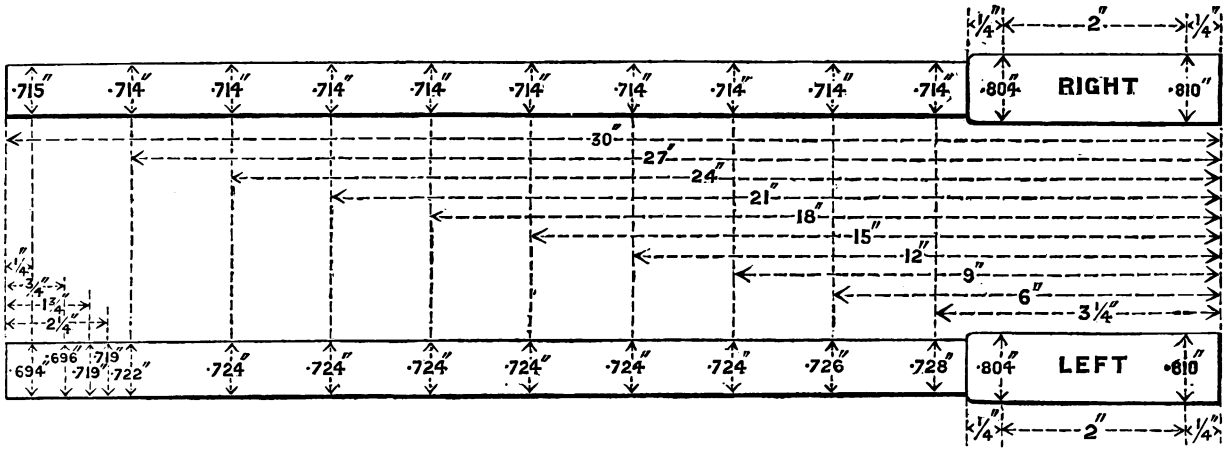
No. 5 GUN.—Right barrel cylindrical, left barrel full choke.



		Cartridges.					
		B.	D.	N.	*P. Schultze powder.	*Q. Schultze powder.	*S. E. C. powder.
		f. s.	f. s.	f. s.	f. s.	f. s.	f. s.
Mean muzzle velocities	Right barrel ...	1115·6	1317·4	1390·6	1356	1440	1366
	Left barrel	1119·2	1388	1399·2	1353	1356·5	1349

* Mean of two rounds only.

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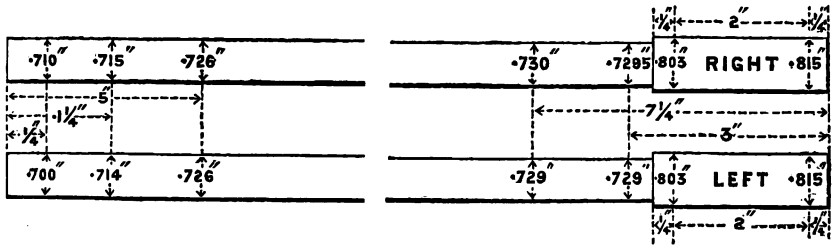
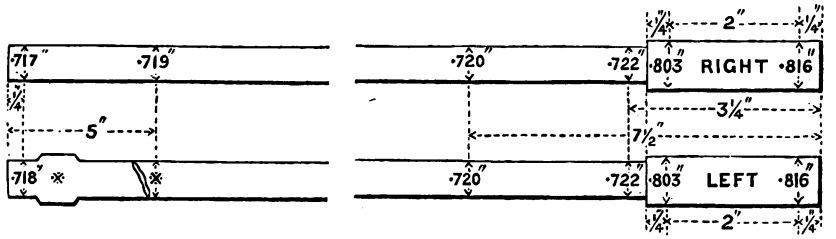
No. 6 GUN.—Right barrel modified choke, left barrel full choke.



		Cartridges. D.
		f. s.
Mean muzzle velocities	Right barrel. ...	1317·8
	Left barrel.....	1311·8

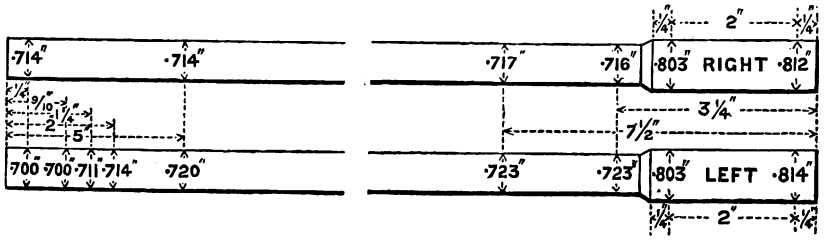
No. 7 GUN.—Right barrel cylindrical, left barrel modified choke.



* A cast of these parts could not be taken.

		Cartridges. D.
		f. s.
Mean muzzle velocities	Right barrel. ...	1271·2
	Left barrel.....	1309·6

No. 8 GUN.—Right barrel cylindrical, left barrel full choke.



		Cartridges. D.
		f. s.
Mean muzzle velocities	Right barrel....	1264·6
	Left barrel.....	1302·2

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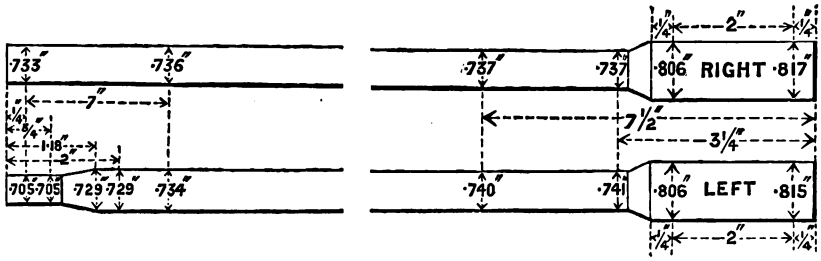
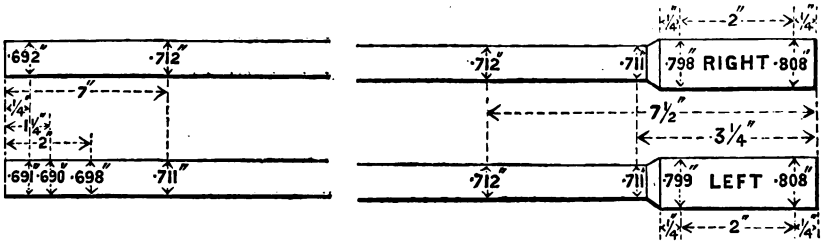
No. 9 GUN.—Right barrel cylindrical, left barrel full choke.



		Cartridges.		
		A.	E.	M.
		f. s.	f. s.	f. s.
Mean muzzle velocities	Right barrel. ...	1066·6	1042	1313·8
	Left barrel.....	1097·3	1061·2	1345

No. 10 GUN.—Right barrel modified choke, left barrel modified choke.



		Cartridges.			
		D.	H.	K.	L.
		f. s.	f. s.	f. s.	f. s.
Mean muzzle velocities	Right barrel. ...	1323·6	1232·25	1344·8	1363
	Left barrel.....	1334·2	1200·5	1314·8	1365·8

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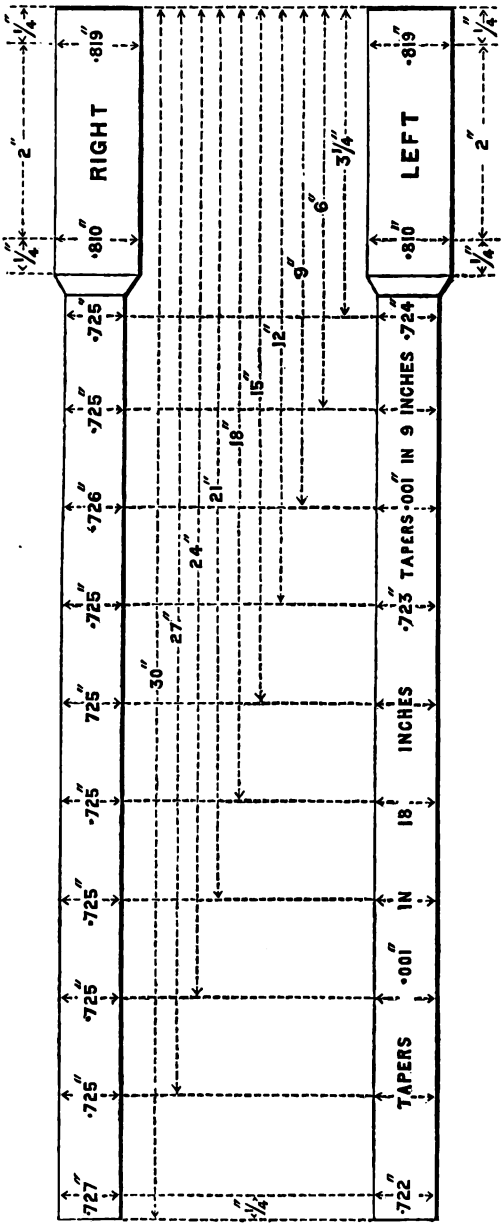

No. 11 Gun.—Right barrel cylindrical, left barrel cylindrical.

	Cartridges.			
	D.	H.	K.	L.
Mean muzzle velocities { Right barrel ...	f. s. 1271·8	f. s. 1164·6	f. s. 1289·75	f. s. 1314·75
Left barrel	1264·5	1155	1294·5	1319·75

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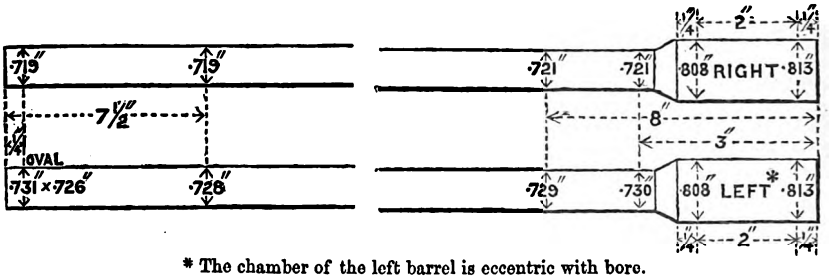
No. 12 GUN.—Right barrel cylindrical, left barrel cylindrical.



* The chamber of the left barrel is eccentric with bore.

		Cartridges.		
		H.	K.	L.
			f. s.	f. s.
Mean muzzle velocities	Right barrel....	1203·25	1328·6	1359·6
	Left barrel.....	1238·4	1326·4	1369·6

According to the Proof Act, a 13-bore has a diameter of 0·710″ a 12-bore a diameter of 0·729″ and an 11-bore a diameter of 0·751″; but it will be noted that the following barrels, although marked "13," were in reality 12-bores:—

	Right barrel.	Left barrel.
	inch.	inch.
No. 1 Gun	0·749	—
No. 2 "	0·732	0·730
No. 6 "	0·730	0·729
No. 9 "	0·737	0·741
No. 12 "	—	0·730

These barrels were no doubt correct to gauge when marked, but have become enlarged by careless cleaning, or lapping out to remove rust, &c. The right barrel of No. 1 gun was lapped out to its present size by a local gunmaker, to remove a surface flaw in the bore. Of course it was most desirable to try both good and bad barrels in these experiments, in order that the results might be more instructive than if only good barrels were tested.

When it is remembered that at different times gunmakers have professed to improve the shooting of their guns by:—1. Enlarging the breech; 2. Enlarging the bore both at breech and muzzle; 3. Choking the muzzle on half a dozen different plans; it must be admitted that the desired result is not likely to be obtained by each of these methods, and that it is possible we have yet to discover the best form of bore to fire a given size of wad.

Having given the above particulars about each of the guns tried, it will perhaps assist the reader if all the mean velocities noted be placed before him in a tabular form. Bearing in mind the dimensions of each barrel, he may be able to form some opinion why one gun

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gave more velocity than another, the same cartridges being used with each.

Cartridges.	Barrels.	Mean Muzzle Velocity of Five Rounds Fired from each Barrel.											
		No. 1 Gun.	No. 2 Gun.	No. 3 Gun.	No. 4 Gun.	No. 5 Gun.	No. 6 Gun.	No. 7 Gun.	No. 8 Gun.	No. 9 Gun.	No. 10 Gun.	No. 11 Gun.	No. 12 Gun.
		f. s.	f. s.	f. s.	f. s.	f. s.	f. s.	f. s.	f. s.	f. s.	f. s.	f. s.	f. s.
A. Measured charges.	Right	1035·4	1091·2	...	...	...	...	...	...	1066·6	...	...	...
	Left.....	1098·6	1087	...	...	...	...	...	...	1097·3	...	...	...
B. Weighed charges.	Right	...	1082	...	...	1115·6	...	...	...	...	...	...	...
	Left.....	...	1067·6	...	...	1119·2	...	...	...	...	...	...	...
C. Measured charges.	Right	...	1314	...	...	...	...	...	...	...	...	...	...
	Left.....	...	1274·4	...	...	...	...	...	...	...	...	...	...
D. Weighed charges.	Right	..	1278	...	...	1317·4	1317·8	1271·2	1264·6	...	1323·6	1271·8	...
	Left.....	...	1290	...	...	1338	1311·8	1309·6	1302·2	...	1334·2	1264·5	...
E. Measured charges.	Right	1008·4	1048·6	...	...	...	...	...	...	1042	...	...	...
	Left.....	1069	1045·2	...	...	...	...	...	...	1061·2	...	...	...
F. Weighed charges.	Right	...	1075·4	...	...	...	...	...	...	...	...	...	...
	Left.....	...	...	...	...	...	...	...	...	...	...	...	...
G. Measured charges.	Right	...	1073·2	...	...	...	...	...	...	...	...	...	...
	Left.....	...	1058·2	...	...	...	...	...	...	...	...	...	...
H. Weighed charges.	Right	...	1180	1171·6	1195·8	...	...	...	...	...	1232·25	1164·6	1203·25
	Left.....	...	1177·8	1163·4	1182·8	...	...	...	...	...	1200·5	1155	1238·4
K. Weighed charges.	Right	...	1293·6	...	...	...	...	...	...	...	1344·8	1289·75	1328·6
	Left.....	...	1271·4	...	...	...	...	...	...	...	1314·8	1294·5	1326·4
L. Weighed charges.	Right	...	1336·4	...	...	...	...	...	...	...	1363	1314·75	1359·6
	Left.....	...	1303·8	...	...	...	...	...	...	...	1365·8	1319·75	1369·6
M. Measured charges.	Right	1260·8	1316·6	...	...	...	...	...	...	1313·8	...	...	...
	Left.....	1317·8	1335	...	...	...	...	...	...	1345	...	...	...
N. Weighed charges.	Right	1281	1351·8	1349·6	1363·6	1390·6	...	...	...	...	...	...	...
	Left.....	1355	1359·4	1341·3	1352·3	1399·2	...	...	...	...	...	...	...

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It must not be forgotten that the diameter of the wads for 12-bore paper cases is about ·735 in.; and that, though on discharge the wads may be compressed, or slightly expanded to the size of the bore immediately in front of the chamber, and afterwards may be still further compressed as they pass up the barrel, still they cannot be expected to expand again when they reach a wide place in the bore. Here it is that the gas gets past the wad, and leaves the bore along with the shot instead of behind it, and when this happens, the shot is scattered, and the muzzle velocity reduced. The "choke-bore," to a certain extent, remedies any windage which may exist, or at least does so as the shot leaves the muzzle, and so prevents the scattering of the pellets (and loss of velocity to some extent) which occurs when they and the gas issue from the barrel together. Thus it will be seen that the choke in the barrel is of advantage when the barrel is badly bored, or where wads which do not perfectly seal the bore behind the shot (so preventing windage) are used. Gun barrels can be bored to an exact gauge, but it is impossible to guarantee that the diameters of paper cases and wads do not vary to a certain extent, considering the materials of which they are composed; so, to allow for the wad receiving the necessary amount of compression as it enters the bore, the breech end of the barrel must not be bored too wide. A wad which is too tight for the barrel will, of course, cause loss of velocity.

A loss in muzzle velocity is also caused by the cartridge chambers being too large, a very common defect in old or carelessly made guns; and it will be noticed how greatly the chambers of the guns used in these experiments varied in capacity.

When we look at the table of mean velocities, we regret that one sample of ammunition could not be used to test all the guns; but, as already stated, this was impossible, as no two boxes contained cartridges loaded with powder of the same quality. Something, however, may be learned by noting the results with each gun.

For instance, we see that the right barrel of No 1 gun is inferior to the left every time it was tried; the reason being that its diameter at the breech was ·749 inch, so that the bore could not be sealed by the wads behind the shot, and, some of the gas escaping, the velocity was reduced. The left barrel (although only 28 ins. long) gave as good results as those of four other guns which fired the same cartridges.

Nos. 2, 3, and 4 guns give about the same results when tried with similar ammunition, and the velocities of their right and left barrels are about equal.

No. 5 gun has the right barrel cylindrical and the left full choke. It was found possible to take casts of the whole length of each barrel, owing to their being so well bored, and it will be seen that they give almost the same velocity, and that these velocities are high.

No. 6 gun has the right barrel "modified choke," and the left "full choke." It was only tried with one sample of cartridges, when the right barrel gave rather the higher result, and about the same velocity as that given by the right barrel (cylindrical) of No. 5 gun.

Nos. 7 and 8 guns have the right barrels cylindrical, and the left barrels choked. The right barrels give worse results than other

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cylindrical barrels firing the same ammunition, and the left barrels give better velocity than the right.

No. 9 gun has both barrels bored too wide at the breech; but as the left barrel is choked at the muzzle, the defect is partially remedied, and it invariably gives the higher velocity.

Both barrels of No. 10 gun have "modified choke," and the velocity they give is about the same as that given by Nos. 5 and 6 guns.

No. 11 gun compares unfavourably with the other guns which fired the same samples of ammunition. Complete casts of the barrels were taken, which it is impossible to do when they are badly bored. The loss of velocity, when compared with other guns firing similar cartridges, is probably owing to the chambers being bored too large.

No. 12 gun has both barrels cylindrical, and the velocities given by the right and left barrels are about the same.

The reader must form his own conclusions from the above results as to the merits of the different guns or barrels, bearing in mind that all we know of the bores (with two exceptions) are the measurements of the casts taken of the breech and muzzle ends, leaving an unmeasured interval 17½ ins. in length. What effect the condition of this portion of the barrels may have had on the amount of velocity, it is impossible to say.

The tables which follow give the remaining velocities, times of flight, and striking energies of the three sizes of shot at every ten yards range, when the muzzle velocities vary from 1450 ft. to 1000 ft. per second. Of course, the amount of the striking energy is the information which is of practical use to the sportsman; but in order to calculate it, we must first know the remaining velocity. Over such short ranges the differences in times of flight are of no practical importance, especially as small shot spreads so much as the range increases; but the actual times of flight are given, as the writer has heard many incorrect statements made on this subject.

On examination of these tables it will be seen how greatly the striking energy of the shot falls off as the size of the pellets decreases; and, as the killing power of the shot depends on its energy on striking, this loss of power deserves notice.

If we take the case of all three sizes (Nos. 5, 6, and 8), starting with a muzzle velocity of 1450 ft. per second, we find that at a range of 40 yards the striking energies are as follows :—

No. 5 shot ... 2·22 ft. lb. | No. 6 shot ... 1·53 ft. lb. | No. 8 shot ... 0·907 lb.

And again when they start with a low muzzle velocity of 1000 ft. per second, the energies are :—

No. 5 shot ... 1·52 ft. lb. | No. 6 shot ... 1·07 ft. lb. | No. 8 shot ... 0·647 ft. lb.

Or if we take the case where they start with a muzzle velocity of 1300 ft. per second, which is a fair velocity for good cartridges, the energies at the same range of 40 yards are :—

No. 5 shot ... 1·99 ft. lb. | No. 6 shot ... 1·38 ft. lb. | No. 8 shot ... 0·823 ft. lb.

It has been stated that though the larger sizes of shot may strike the heavier blow, they meet with more resistance owing to their

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greater section, and do not penetrate different substances as far as

No. 5 Shot.—Table I., showing remaining velocity, energy, and time of flight, for ranges up to 70 yards.

Range.	Muzzle velocity = 1450 f. s.			Muzzle Velocity = 1400 f. s.			Muzzle Velocity = 1300 f. s.			Muzzle Velocity = 1200 f. s.			Muzzle Velocity = 1100 f. s.			Muzzle Velocity = 1000 f. s.		
	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.
Yds.	f. s.	ft. lb.	Seconds.	f. s.	ft. lb.	Seconds.	f. s.	ft. lb.	Seconds.	f. s	ft. lb.	Seconds.	f. s.	ft. lb.	Seconds.	f. s.	ft. lb.	Seconds.
10	1142	5·70	0·02315	1168	5·36	0·02121	1043	4·75	0·02592	981	4·21	0·02786	919	3·69	0·0340	852	3·17	0·03253
20	946	3·91	0·0524	924	3·73	0·05108	881	3·39	0·05749	838	3·07	0·06105	793	2·75	0·06512	742	2·41	0·07014
30	812	2·88	0·0869	797	2·78	0·0889	765	2·56	0·0938	732	2·34	0·09226	697	2·12	0·1055	657	1·89	0·1137
40	712	2·22	0·1263	700	2·14	0·1292	675	1·99	0·1358	649	1·84	0·1432	622	1·69	0·151	590	1·52	0·1617
50	634	1·76	0·1708	624	1·70	0·1748	604	1·59	0·1831	584	1·49	0·1914	561	1·38	0·2023	535	1·25	0·2154
60	571	1·42	0·2209	563	1·39	0·2255	547	1·31	0·2351	530	1·23	0·2457	511	1·14	0·2586	490	1·05	0·2735
70	519	1·18	0·2766	513	1·15	0·2814	499	1·09	0·3173	—	—	—	—	—	—	—	—	—

No. 6 Shot.—Table II., showing remaining velocity, energy, and time of flight for ranges up to 60 yards.

Range.	Muzzle Velocity = 1450 f. s.			Muzzle Velocity = 1400 f. s.			Muzzle Velocity = 1300 f. s.			Muzzle Velocity = 1200 f. s.			Muzzle Velocity = 1100 f. s.			Muzzle Velocity = 1000 f. s.		
	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.
Yds.	f. s.	ft. lb.	Seconds.	f. s.	ft. lb.	Seconds.	f. s.	ft. lb.	Seconds.	f. s.	ft. lb.	Seconds.	f. s.	ft. lb.	Seconds.	f. s.	ft. lb.	Seconds.
10	1113	4·17	0·0238	1081	3·94	0·0246	1020	3·51	0·0263	962	3·12	0·0281	902	2·74	0·0303	837	2·36	0·0329
20	910	2·79	0·0538	890	2·67	0·0554	851	2·44	0·0585	810	2·21	0·0623	768	1·99	0·0664	720	1·75	0·0717
30	774	2·02	0·0895	759	1·94	0·0920	730	1·80	0·0968	700	1·65	0·102	668	1·50	0·108	632	1·35	0·116
40	673	1·53	0·131	662	1·48	0·134	639	1·38	0·141	616	1·28	0·148	591	1·18	0·157	563	1·07	0·166
50	595	1·19	0·179	586	1·16	0·183	569	1·09	0·191	550	1·02	0·200	530	0·947	0·210	507	0·867	0·223
60	533	0·958	0·233	526	0·933	0·237	512	0·884	0·247	497	0·833	0·257	—	—	—	—	—	—
70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

smaller shot. This statement is totally incorrect, because the resistance

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the pellets meet with when flying through the air, or on striking any

No. 8 Shot.—Table III., showing remaining velocity, energy, and time of flight, for ranges up to 50 yards.

Range.	Muzzle Velocity = 1450 f. s.			Muzzle Velocity = 1400 f. s.			Muzzle Velocity = 1300 f. s.			Muzzle Velocity = 1200 f. s.			Muzzle Velocity = 1100 f. s.			Muzzle Velocity = 1000 f. s.		
	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.
Yds.	f. s.	ft. lb.	Seconds.	f. s.	ft. lb.	Seconds.	f. s.	ft. lb.	Seconds.	f. s.	ft. lb.	Seconds.	f. s.	ft. lb.	Seconds.	f. s.	ft. lb.	Seconds.
10	1080	2·66	0·02117	1050	2·52	0·02501	994	2·26	0·02065	938	2·01	0·02864	882	1·78	0·03066	820	1·54	0·03321
20	870	1·73	0·05535	852	1·66	0·05684	815	1·52	0·06027	778	1·38	0·06387	739	1·25	0·06795	695	1·10	0·07307
30	731	1·22	0·09294	718	1·18	0·09528	692	1·09	0·1001	665	1·01	0·1054	636	0·924	0·1118	603	0·831	0·1195
40	630	0·907	0·1372	620	0·878	0·1405	600	0·823	0·1472	580	0·768	0·1541	558	0·711	0·1623	532	0·647	0·1730
50	553	0·699	0·1886	546	0·681	0·1920	531	0·644	0·1998	515	0·606	0·2086	497	0·565	0·2195	—	—	—
60	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

substance, is proportionate to the squares of their diameters, while their

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power to overcome such resistance is proportional to the cubes of their diameters. Thus it will be seen that when different sizes of shot start with equal muzzle velocities, the penetrative power at any range is the greater the larger the size of the pellets.

Now to compare how the size of the shot affects the range.

Taking the muzzle velocity of 1300 feet per second, we can compare the ranges at which the three sizes of shot will strike approximately the same blow, and find them to be as follows :—

Shot.	Energy.	Range.
No. 5	1·09 ft. lb.	70 yards.
No. 6	1·09 "	50 "
No. 8	1·09 "	30 "

Again, when the muzzle velocity is 1000 feet per second, which is not an unusual velocity for cartridges to give when they are bought filled, we find :—

Shot.	Energy.	Range.
No. 5	1·05 ft. lb.	60 yards.
No. 6	1·07 "	40 "
No. 8	1·10 "	20 "

Or, if we take the case of a high muzzle velocity of 1450 feet per second :—

Shot.	Energy.	Range.
No. 5	1·18 ft. lb.	70 yards.
No. 6	1·19 "	50 "
No. 8	1·22 "	30 "

It would be useless to make further comparisons, as the reader can do this for himself, and can form his own opinion as to the most suitable size of shot to use.

The reader will now naturally ask himself the following questions :—

1. Are the above results of any practical value ?
2. Do we know enough about the interior of our gun barrels, and of the contents of the cartridges we use for game shooting ?
3. When we buy cartridges should not we insist on receiving a guarantee that they will give a certain muzzle velocity (which should be marked on each box) when fired from a standard barrel ?

No doubt both the gun trade and the cartridge makers will oppose any change in the present system, and will prefer that their customers should buy whatever they give them ; but the matter lies wholly in the hands of the customers, and *what they insist on having they will get.*

[NOTE.—When this paper was originally published in the "*Field*" the dimensions of the chambers of the barrels were not given. Colonel G. H. J. A. Fraser, Royal Artillery, having kindly drawn my attention to this defect, the omission has now been rectified.—*W. McC.*]

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PROBLEMS IN GUNNERY.

BY

MAJOR W. McCLINTOCK, R.A.,

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In No. 5, Vol. IX., "Proceedings, Royal Artillery Institution," there is a paper by Captain J. Sladen, R.A. (now Colonel Sladen), on "The application of Professor Bashforth's general tables to Problems in Practical Gunnery"; the general tables being:—

$$\frac{d^2}{w} S = S_v - S_V \quad \text{Distance and Velocity Table.}$$

$$\frac{d^2}{w} T = T_v - T_V \quad \text{Time and Velocity Table.}$$

Also, in "Principles of Gunnery, Rifled Ordnance," and in the "Handbook for Field Service, 1878," Colonel Sladen has given similar examples worked out with the aid of the above tables, and some examples in which the calculations are made with the aid of a third table, viz.:—

$$\frac{d^2}{w} D = D_v - D_V \quad \text{Inclination and Velocity Table,}$$

by Mr. W. D. Niven, M.A., (see "Proceedings of the Royal Society," No. 181, 1877.)

The above tables were calculated from the results obtained from the earlier experiments made with the Bashforth chronograph at Shoeburyness; but in 1880 Professor Bashforth published his final report, giving new tables which combined the results of experiments made in 1867–68, and those with projectiles moving with very high and low velocities carried out in 1878–80.

Mr. Niven has also calculated a new table based on the latest results.

These tables are:—

1. $\frac{d^2}{w} T = T_V - T_v$ Time and Velocity Table.
2. $\frac{d^2}{w} S = S_V - S_v$ Distance and Velocity Table.
3. $\frac{d^2}{w} D = D_V - D_v$ Inclination and Velocity Table.

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The following examples are similar to those given by Col. Sladen, but are worked out using the latest tables :—

Application of Professor Bashforth's general tables (as given in his final report of 31. 8. 80.) to problems connected with the flight of the rifle bullet and other elongated projectiles.

These general tables are applicable to any elongated projectile with an ogival head, when its weight and diameter are known.

Let d = diameter of bullet in inches.

w = weight of bullet in lbs.

S = range in feet.

T = time of flight in seconds.

Then $\frac{d^2}{w}T = T_V - T_v$ (Table I.)

and $\frac{d^2}{w}S = S_V - S_v$ (Table II.)

EXAMPLES.

1. With what velocity would a Martini-Henry bullet strike a target at a 1000 yards range ?

Muzzle velocity = 1315 feet per second.

$d = 0{\cdot}45$-inch.

$w = 480$ grains $= \frac{480}{7000}$ lbs.

$S = 1000$ yards $= 3000$ feet.

$\frac{d^2}{w}S = S_V - S_v$; therefore $S_{1315} - S_v = 2{\cdot}953 \times 3000 = 8859$ feet.

$S_v = S_{1315} - 8859$ feet.

Now, corresponding to velocity 1315 f.s. in Table II., we find—

$$S_{1315} = \overset{\text{feet.}}{42259{\cdot}8}$$
$$\text{subtracting} \quad 8859$$
$$33400{\cdot}8 = S_v;$$

which, by an inverse process in the same table, corresponds to a velocity of 664 feet per second. Therefore the striking velocity of the bullet at 1000 yards range is 664 feet per second.

2. With what velocity would a Martini-Henry bullet be moving at the end of 3 seconds ?

$\frac{d^2}{w}T = T_V - T_v$

$T_{1315} - T_v = \frac{d^2}{w}T = 2{\cdot}953 \times 3 = 8{\cdot}859$ seconds.

$T_v = T_{1315} - 8{\cdot}859$ seconds.

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Corresponding to velocity 1315 f.s. in Table I., we find—

$$\begin{array}{rr} & \text{seconds.} \\ T_{1315} = & 231{\cdot}6690 \\ \text{subtracting} & 8{\cdot}859 \\ \hline & 222{\cdot}810 = T_v; \end{array}$$

which, by an inverse process in the same table, corresponds to a velocity of 701 feet per second, nearly. Therefore the remaining velocity of the bullet after 3 seconds' time of flight is about 701 f.s.

3. What would be the time of flight of a Martini-Henry bullet over a range of 1000 yards?

From Example (1) we know that the remaining velocity of the bullet at 1000 yards = 664 f.s.; so that the question becomes:—In what *time* would the velocity of the Martini-Henry bullet be reduced from 1315 to 664 f.s.?

$$\frac{d^2}{w} T = T_V - T_v$$

$$T_{1315} - T_{664} = \frac{d_2}{w} T = 2{\cdot}953\, T.$$

In Table I., we find—

$$\begin{array}{rr} & \text{seconds.} \\ & T_{1315} = 231{\cdot}6690 \\ \text{and} & T_{664} = 221{\cdot}4797 \\ \text{subtracting} & \hline & 10{\cdot}1893. \end{array}$$

Hence $2{\cdot}953\, T = 10{\cdot}1893$

$$\therefore\ T = 3{\cdot}4504 \text{ seconds.}$$

4. At what range would the velocity of a Martini-Henry bullet be reduced from 1315 to 700 f.s.?

$$\frac{d^2}{w} S = S_V - S_v$$

$$S_{1315} - S_{700} = \frac{d^2}{w} S = 2{\cdot}953\, S.$$

In Table II., we find—

$$\begin{array}{rr} & \text{feet.} \\ & S_{1315} = 42259{\cdot}8 \\ \text{and} & S_{700} = 34280{\cdot}4 \\ \text{subtracting} & \hline & 7979{\cdot}4; \end{array}$$

or $2{\cdot}953\, S = 7979{\cdot}4$

$$\therefore\ S = 2702{\cdot}1 \text{ feet} = 900{\cdot}7 \text{ yards.}$$

5. The time of flight of a Snider bullet is observed to be 3 seconds;

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the muzzle velocity is known to be 1240 f.s. Find the striking velocity and the range.

$w = 480$ grains. $d = 0{\cdot}577$-inch.

$$\frac{d^2}{w} T = T_V - T_v$$

$$T_{1240} - T_v = \frac{d^2}{w} T = 4{\cdot}855 \times 3 = 14{\cdot}565 \text{ seconds.}$$

$$T_v = T_{1240} - 14{\cdot}565 \text{ seconds.}$$

Corresponding to velocity 1240 f.s. in Table I., we find—

$$T_{1240} = \overset{\text{seconds.}}{231{\cdot}3381}$$

subtracting $\quad 14{\cdot}565$

$$216{\cdot}7731 = T_v,$$

which corresponds to a velocity in the same table of 559 f.s., nearly. Therefore striking velocity = 559 f.s.

To find the range :—

$$\frac{d^2}{w} S = S_V - S_v$$

$$S_{1240} - S_{559} = \frac{d^2}{w} S = 4{\cdot}885\, S.$$

In Table II., we find—

$$S_{1240} = \overset{\text{feet.}}{41837{\cdot}5}$$

and $\quad S_{559} = 30534{\cdot}3$

subtracting

$$11303{\cdot}2;$$

Hence $4{\cdot}855\, S = 11303{\cdot}2$

$\therefore\ S = 2328{\cdot}15$ feet $= 776$ yards.

Therefore range $= 776$ yards.

6. The range of a Snider bullet is observed to be 900 yards. Its muzzle velocity is 1240 f.s. Find its striking velocity and time of flight.

$$\frac{d^2}{w} S = S_V - S_v$$

$$S_{1240} - S_v = \frac{d^2}{w} S = 4{\cdot}855 \times 900 \times 3 = 13108{\cdot}5 \text{ feet.}$$

$$S_v = S_{1240} - 13108{\cdot}5 \text{ feet.}$$

Corresponding to velocity 1240 f.s. in Table II., we find—

$$S_{1240} = \overset{\text{feet.}}{41837{\cdot}5}$$

subtracting $\quad 13108{\cdot}5$

$$28729{\cdot}0 = S_v;$$

which corresponds in the same table to 501 f.s., nearly. Therefore the velocity on striking = 501 f.s.

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To find the time of flight:—

$$\frac{d^2}{w} T = T_V - T_v$$

$$T_{1240} - T_{501} = \frac{d^2}{w} T = 4{\cdot}855\ T.$$

In Table I., we find—

		seconds.	
	T_{1240}	= 231·3381	
and	T_{501}	= 213·3814	subtracting
		17·9567	

therefore $4{\cdot}855\ T = 17{\cdot}9567$

and $T = 3{\cdot}698$ seconds;

Therefore time of flight = 3·698 seconds.

Approximate Method of Finding Trajectories.

7. Find the trajectory of the Martini-Henry rifle at 500 yards range. Weight of bullet = 480 grains. Diameter of bore = 0·45-inch. M.V. = 1315 f.s.

Points on the trajectory at any required intervals can be found, and in this example we will find them for every hundred yards. First, by Table II., the remaining velocity at every hundred yards (300 feet) must be found:—

$$\frac{d^2}{w} S = S_V - S_v$$

$$S_{1315} - S_v = \frac{d^2}{w} S = 2{\cdot}953 \times 300 = 885{\cdot}9 \text{ feet.}$$

$$S_v = S_{1315} - 885{\cdot}9 \text{ feet.}$$

In Table II. for velocity 1315	42259·8		
subtract	885·9	f.s.	yds.
	41373·9	= 1167	at 100.
	885·9		
	40488·0	= 1053	„ 200.
	885·9		
	39602·1	= 982	„ 300.
	885·9		
	38716·2	= 922	„ 400.
	885·9		
	37830·3	= 869	„ 500.

which gives us the remaining velocity at every 100 yards.

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The next step is to find the time of flight for each distance.

1. To find time for 100 yards range, remaining vel. = 1167 f.s.

$$T_{1315} - T_{1167} = \frac{d^2}{w} T = 2{\cdot}953\ T.$$

In Table I., for velocity 1315 = 231·6690
" 1167 = 230·9548

0·7142

$\therefore$ 2·953 T = 0·7142 secs.

$$T = \frac{0{\cdot}7142}{2{\cdot}953} = 0{\cdot}24186 \text{ secs.}$$

2. Time over 200 yards, remaining vel. = 1053 f.s.

For velocity 1315 = 231·6690
" 1053 = 230·1520

1·5170

$$T = \frac{1{\cdot}5170}{2{\cdot}953} = 0{\cdot}51372 \text{ secs.}$$

3. Time over 300 yards, remaining vel. = 982 f.s.

For velocity 1315 = 231·6690
" 982 = 229·2737

2·3953

$$T = \frac{2{\cdot}3953}{2{\cdot}953} = 0{\cdot}81114 \text{ secs.}$$

4. Time over 400 yards, remaining vel. = 922 f.s.

For velocity 1315 = 231·6690
" 922 = 228·3432

3·3258

$$T = \frac{3{\cdot}3258}{2{\cdot}953} = 1{\cdot}1262 \text{ secs.}$$

5. Time over 500 yards, remaining vel. = 869 f.s.

For velocity 1315 = 231·6690
" 869 = 227·3549

4·3141

$$T = \frac{4{\cdot}3141}{2{\cdot}953} = 1{\cdot}4609 \text{ secs.}$$

These results may be collected in a tabular form, as follows:—

Distance.		Remaining velocity.		Time of flight.
0 yds.	.....	1315 f.s.	.....	0·000 secs.
100 "	.....	1167 "	.....	0·24186 "
200 "	.....	1053 "	.....	0·51372 "
300 "	.....	982 "	.....	0·81114 "
400 "	.....	922 "	.....	1·1262 "
500 "	.....	869 "	.....	1·4609 "

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When the time over a given range is known, the corresponding height of the trajectory is found by the equation—

$$y = \frac{g}{2} t\,(T - t);$$

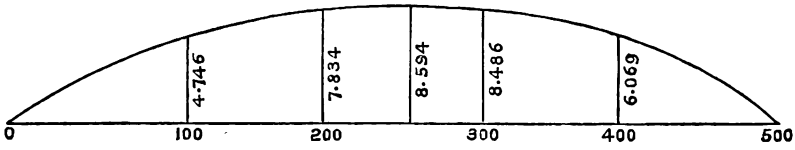
where T is the whole time of flight, and t the time over given range.

Thus, at 100 yds. $t = 0{\cdot}24186$, and $(T - t) = 1{\cdot}2190$; $g = 32{\cdot}2$.

$y_{100} = 16{\cdot}1 \times 0{\cdot}24186 \times 1{\cdot}2190 = 4{\cdot}746$ feet.
$y_{200} = 16{\cdot}1 \times 0{\cdot}51372 \times 0{\cdot}9472 = 7{\cdot}834$ "
$y_{300} = 16{\cdot}1 \times 0{\cdot}81114 \times 0{\cdot}6498 = 8{\cdot}486$ "
$y_{400} = 16{\cdot}1 \times 1{\cdot}1262 \times 0{\cdot}3347 = 6{\cdot}069$ "
$y_{500} = 16{\cdot}1 \times 1{\cdot}4609 \times 0 = 0$ "

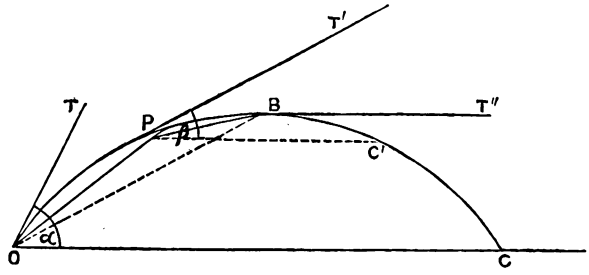
Greatest height of trajectory $= \frac{g}{8} T^2 = \frac{32{\cdot}2}{8} (1{\cdot}4609)^2 = 8{\cdot}594$ ft.

TRAJECTORY OF MARTINI-HENRY RIFLE AT 500 YARDS.



For low angles of elevation, trajectories computed on this principle are very approximately correct.

Table III. is useful for computing the remaining velocity at the end of a given arc, or for computing the arc for a given change in velocity.



Thus, if OBC be the trajectory of a projectile, B the vertex of trajectory, OT, PT', BT'' tangents to the trajectory at the points O,P,B,

$$TOC = \alpha, \quad T'PC' = \beta;$$

and if $D = \alpha - \beta$ in degrees, V = horizontal muzzle velocity, and v = horizontal remaining velocity at end of arc OP, then

$$\frac{d^2}{w} D = D_V - D_v$$

N.B.—At the vertex of the trajectory $\beta = O$; in this case $D = \alpha$, the angle of departure.

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Examples.

8. What is the remaining velocity at the vertex of the trajectory of a Martini-Henry rifle when fired with an angle of elevation of 3°?

Muzzle velocity = 1315 f.s. $d = 0{\cdot}45$-inch. $w = 480$ grains.

$$\frac{d^2}{w} D = D_V - D_v$$

$$2{\cdot}953 \times 3 = D_{1315} - D_v$$

$$D_v = D_{1315} - 8{\cdot}859.$$

Corresponding to velocity 1315 f.s. in Table III., we find—

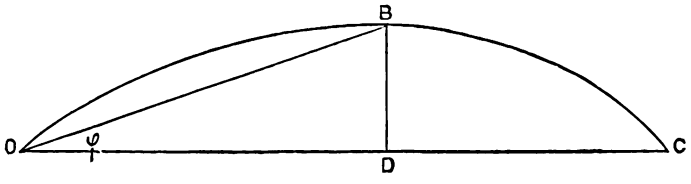
$$D_{1315} = \overset{\text{degrees.}}{83{\cdot}0893}$$

subtracting $\quad 8{\cdot}859$

$$74{\cdot}2303 = D_v\ ;$$

which, by an inverse process in the same table, corresponds to a velocity of 847 f.s., nearly. Therefore the velocity at vertex = 847 f.s.

To determine the horizontal distance from the muzzle to a perpendicular let fall from the vertex on the horizontal plane.



Let angle $B\,O\,D = \phi$,

$O\,B = S$,

$O\,D = X$,

$B\,D = Y$,

then $\quad X = S \cos \phi$, and $Y = S \sin \phi$.

The approximate value of ϕ (the angle which the chord of an arc makes with the horizontal line in terms of the angles made by the tangents to the trajectory at the extremities of the arc with the horizontal plane) is, in the ascending arc,—

$$\frac{\alpha + \beta}{2} + \frac{V - v}{V} \times \frac{\alpha + \beta}{6}.$$

At the vertex $\beta = 0$; so that in this case—

$$\phi = \frac{\alpha}{2} + \frac{V - v}{V} \times \frac{\alpha}{6}$$

As shown above $\quad X = S \cos \phi$,

or $\quad S = \dfrac{X}{\cos \phi}$;

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substituting this value for S in the equation

$$\frac{d^2}{w}S = S_V - S_v,$$

we have

$$\frac{d^2}{w}\frac{X}{\cos\phi} = S_V - S_v$$

where v = velocity at vertex, and V = horizontal muzzle velocity; or

$$X = \frac{\cos\phi\,(S_V - S_v)}{\frac{d^2}{w}}.$$

9. Find the horizontal distance from the muzzle to a perpendicular let fall from the vertex of trajectory in the horizontal plane when a Martini-Henry rifle is fired with an angle of elevation of 3° (*see last Example*).

$$X = \frac{\cos\phi\,(S_V - S_v)}{\frac{d^2}{w}}$$

Neglecting cos ϕ, which is very small for small angles, we get—

$$X = \frac{S_{1315} - S_{847}}{2{\cdot}953}.$$

In Table II. we find—

		feet.
	S_{1315}	= 42259·8
and	S_{847}	= 37434·4
		4825·4

so

$$X = \frac{4825{\cdot}4}{2{\cdot}953} = 1634 \text{ feet} = 544{\cdot}6 \text{ yards}.$$

Therefore the horizontal distance = 544·6 yards.

To determine the time the projectile takes in travelling to its highest point.

$$\frac{d^2}{w}T = T_V - T_v$$

$$\therefore \quad T = \frac{T_V - T_v}{\frac{d^2}{w}};$$

where v = velocity at vertex, and V = horizontal muzzle velocity.

10. To find the time the Martini-Henry bullet takes to reach the highest point of its trajectory, when the rifle is fired with an angle of elevation of 3° (*see Example 8*).

$$\frac{d^2}{w}T = T_V - T_v$$

$$T = \frac{T_{1315} - T_{847}}{2{\cdot}953}.$$

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In Table I. we find—

$$\begin{array}{rl} & \text{seconds.} \\ T_{1315} & = 231{\cdot}6690 \\ T_{847} & = 226{\cdot}8895 \\ \hline & 4{\cdot}7795 \end{array}$$

so $$T = \frac{4{\cdot}7795}{2{\cdot}953} = 1{\cdot}618 \text{ seconds.}$$

Therefore time = 1·618 seconds.

To determine the height of the highest point in the trajectory above the horizontal plane passing through the axis of the rifle.

$$Y = S \sin \phi; \text{ so } S = \frac{Y}{\sin \phi};$$

substituting this value for S in the equation

$$\frac{d^2}{w} S = S_V - S_v$$

we get $$\frac{d^2}{w} \frac{Y}{\sin \phi} = S_V - S_v;$$

where v = velocity at vertex, and V = horizontal muzzle velocity :

or $$Y = \frac{\sin \phi \ (S_V - S_v)}{\frac{d^2}{w}}$$

11. Find the height of the highest point of trajectory of a Martini-Henry rifle when fired with an elevation of 3°.

$$Y = \frac{\sin \phi (S_V - S_v)}{\frac{d^2}{w}};$$

$$\therefore Y = \sin \phi \times 1634 \text{ feet.} \quad (\textit{See Example 9}).$$

But $$\phi = \frac{a}{2} + \frac{V - v}{V} \times \frac{a}{6} = \frac{3}{2} + \frac{1315 - 847}{1315} \times \frac{3}{6}$$

$$= 1° \ 30' + \frac{468 \times 3 \times 60'}{1315 \times 6} = 1° \ 30' + \frac{2808'}{263} = 1° \ 40'.$$

$$\therefore Y = 1634 \sin 1° \ 40' = 47{\cdot}524 \text{ feet.}$$

Therefore, height of highest point of trajectory = 47·524 feet.

Table III. enables us to determine the remaining velocity at the end of the given arc; so that, knowing the velocity at the vertex, the velocity at the end of an arc whose tangent is inclined at 5° (suppose) to the horizontal line may be determined thus from the equation :—

$$\frac{d^2}{w} D = D_V - D_v$$

or $$D_v = D_V - \frac{d^2}{w} D.$$

N.B.—It is necessary to *assume* an angle of descent as nearly *correct* as possible, in order to save extra calculation.

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12. Assuming the angle of descent of a Martini-Henry bullet to be 5° when the rifle is fired with an angle of elevation of 3°, find the remaining velocity at the end of the trajectory.

Velocity at vertex, or $V = 847$ f.s. (found by *Example* 8) $\frac{d^2}{w} = 2{\cdot}953$. $D = 5°$.

Substituting these values in equation—

$$D_v = D_V - \frac{d^2}{w} D, \text{ we have}$$

$$D_v = D_{847} - 2{\cdot}953 \times 5 = D_{847} - 14{\cdot}765.$$

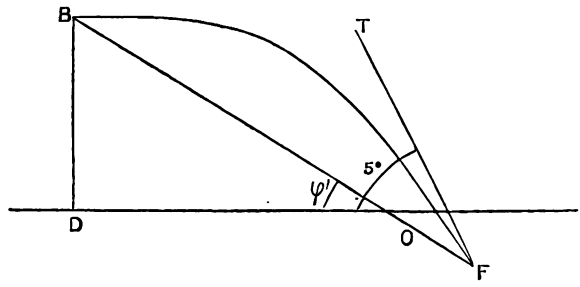
In Table III. we find—

	degrees.
	$D_{847} = 74{\cdot}2546$
subtracting	$14{\cdot}765$
	$59{\cdot}4896 = D_v$;

which, by an inverse process in the same table, corresponds to a velocity of 652 f.s., nearly. Therefore the remaining velocity = 652 f.s.

Now, the range in which the velocity would be reduced from 847 to 652 f.s. may be found by Table II. and the equation :—

$$X' = \frac{\cos \phi' \, (S_V - S_v)}{\frac{d^2}{w}} \qquad (\textit{See Example 9}).$$



Neglecting cos ϕ', which is very small,—

$$X' = \frac{S_{847} - S_{652}}{2{\cdot}953}$$

In Table II. we find—

	feet.
S_{847}	$=37434{\cdot}4$
S_{652}	$=33088{\cdot}5$
	$4345{\cdot}9$

$$\therefore X' = \frac{4345{\cdot}9}{2{\cdot}953} = 1471{\cdot}7 \text{ feet} = 490{\cdot}5 \text{ yards}.$$

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The vertical height fallen through from vertex is—

$$Y' = \frac{\sin \phi' \, (S_V - S_v)}{\frac{d^2}{w}} \quad (\textit{See Example 11}).$$

The approximate value of ϕ' for the descending curve is—

$$\phi' = \frac{\beta}{2} - \frac{V - v}{V} \times \frac{\beta}{6},$$

where β is the angle which the direction of motion makes with the horizontal line at the end of the arc. In this case $\beta = 5°$, thus—

$$\phi' = \frac{5}{2} - \frac{847 - 652}{847} \times \frac{5}{6}$$

$$= 2° \ 30' - \frac{195 \times 5 \times 60'}{847 \times 6}$$

$$= 2° \ 30' - 11' = 2° \ 19';$$

or

$$Y' = \frac{\sin 2° \ 19' \, (S_{847} - S_{652})}{\frac{d^2}{w}}$$

$$= \sin 2° \ 19' \times 1471{\cdot}7 \text{ feet},$$

$$= 59{\cdot}49 \text{ feet}.$$

But by Example (11) we found that $Y = 47{\cdot}524$ feet, therefore $59{\cdot}49 - 47{\cdot}524 = 11{\cdot}966$ feet; or the bullet, with an angle of descent of 5°, strikes 11·966 feet below the horizontal line through the axis of the rifle.

From Example (9)—

$$X = 1634 \text{ feet}$$

and $$X' = 1471{\cdot}7 \text{ " } \quad \text{(as found above)}.$$

Or total range $(X + X') = 3105{\cdot}7$ feet $= 1035{\cdot}2$ yards.

Or 1035·2 yards is the range of the Martini-Henry rifle when fired with an angle of elevation of 3°, and when the bullet strikes the ground 11·966 feet below the horizontal line through the axis of the rifle.

To determine the total time of flight over the range.

By Example (10) the time of flight to the vertex = 1·618 seconds. The time of flight to a point 11·966 feet below the horizontal line can be found by Table I. and the equation—

$$\frac{d^2}{w} T' = T_V - T_v$$

for

$$T' = \frac{T_{847} - T_{652}}{2{\cdot}953}$$

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In Table I. we find—

$$\begin{array}{r} \text{seconds.} \\ T_{847} = 226{\cdot}8895 \\ T_{652} = 221{\cdot}0151 \\ \hline 5{\cdot}8744 \end{array}$$

$$\therefore\ T' = \frac{5{\cdot}8744}{2{\cdot}953} = 1{\cdot}989 \text{ seconds.}$$

From Example (10)—

$$\begin{array}{rr} & \text{seconds.} \\ & T = 1{\cdot}618 \\ \text{and} & T' = 1{\cdot}989 \\ \hline \text{Therefore} & T + T' = 3{\cdot}607 \end{array}$$

Or the total time of flight for a range of 1035·2 yards is 3·607 seconds.

To determine the angle of descent when the range and angle of departure are known.

13. The mean range of the 12-pr. M.L. gun, when fired with 3 lbs. of powder and 3° 27′ quadrant elevation, is found to be 6390 feet on the horizontal plane. What is the angle of descent at that range?

Muzzle velocity = 1680 f.s. Angle of jump = 20′. Angle of departure = 3° 27′ + 20′ = 3° 47′ = 3·783°.

$d = 3$ inches. $w = 12$ lbs. $\frac{d^2}{w} = \frac{9}{12} = \frac{3}{4} = 0{\cdot}75$.

Find remaining velocity over 6390 feet by Table II:—

$$\frac{d^2}{w} S = S_V - S_v$$

$$\frac{9}{12} \times 6390 = S_{1680} - S_v$$

$$\therefore\ S_v = S_{1680} - 4792{\cdot}5.$$

In Table II.—

$$\begin{array}{rr} & \text{feet.} \\ & S_{1680} = 43949{\cdot}0 \\ \text{subtracting} & 4792{\cdot}5 \\ \hline & 39156{\cdot}5 = S_v; \end{array}$$

which, in same table is found to correspond to a velocity of 951 f.s. Therefore the remaining velocity = 951 f.s.

If α be the angle of departure and β the angle of descent—

$$D = \alpha + \beta \text{ in Table III;}$$

substituting this value for D in equation—

$$\frac{d^2}{w} D = D_V - D_v,$$

we have

$$\alpha + \beta = \frac{D_{1680} - D_{951}}{{\cdot}75}.$$

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In Table III. we find—

$$\begin{aligned} &\text{degrees.} \\ D_{1080} &= 84{\cdot}5127 \\ D_{951} &= 78{\cdot}2142 \\ &\hline \\ &6{\cdot}2985 \end{aligned}$$

$$\therefore\ \alpha + \beta = \frac{6{\cdot}2985}{\cdot 75} = 8{\cdot}398°;$$

$$\text{but}\quad \alpha = 3{\cdot}783°;$$

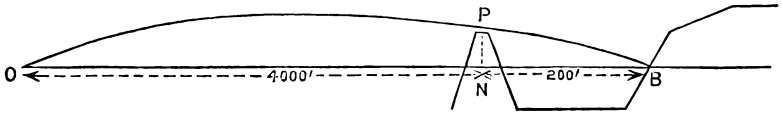
$$\therefore\ \beta = 8{\cdot}398 - 3{\cdot}783 = 4{\cdot}615°;$$

or the angle of descent = 4° 37′.

To find the height of the trajectory at any point when the range is known.

14. A shell fired from a 64-pr. M. L. gun with a charge of 12 lbs. of powder was observed to strike the crest of a traverse 4000 feet distant. Find what vertical distance below the crest of the traverse it would strike an escarp 200 feet beyond. Weight of shell = 64 lbs.; diameter = 6·22 inches; muzzle velocity = 1457 f.s.

$$\frac{d^2}{w} = \frac{(6{\cdot}22)^2}{64} = {\cdot}6045$$



To find the remaining velocity at 4000 feet:—

$$\frac{d^2}{w} S = S_{v'} - S_v$$

$$\text{or}\quad S_v = S_{1457} - {\cdot}6045 \times 4000$$

$$= S_{1457} - 2418.$$

In Table II. we find—

$$\begin{aligned} &\text{feet.} \\ S_{1457} &= 42964{\cdot}1 \\ \text{subtracting}\quad &\quad 2418 \\ &\hline \\ &40546{\cdot}1 = S_v; \end{aligned}$$

which, in the same table, corresponds to a velocity of 1059 f.s.; or v, the remaining velocity at P = 1059 f.s.

To find the remaining velocity at B, 200 feet beyond. In the same manner—

$$S_{v'} = S_{1059} - {\cdot}6045 \times 200$$

$$= S_{1059} - 120{\cdot}90$$

$$\begin{aligned} &\text{feet.} \\ S_{1059} &= 40546{\cdot}1 \\ &\quad 120{\cdot}9 \\ &\hline \\ &40425{\cdot}2 = S_{v'}, \text{ and } v' = 1047 \text{ f.s.} \end{aligned}$$

therefore the remaining velocity at B = 1047 f.s.

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Time over OP is found thus:—

$$T = \frac{T_V - T_v}{\frac{d^2}{w}} = \frac{T_{1457} - T_{1050}}{\cdot 6045}.$$

By Table I.—

	seconds.
T_{1457}	232·1784
T_{1050}	230·2079
	1·9705

$$\therefore\ T = \frac{1\cdot 9705}{\cdot 6045} = 3\cdot 259 \text{ seconds.}$$

Time over PB—

$$T' = \frac{T_v - T_{v'}}{\frac{d^2}{w}} = \frac{T_{1050} - T_{1047}}{\cdot 6045}$$

	seconds.
T_{1050}	230·2079
T_{1047}	230·0923
	0·1156

$$\therefore\ T' = \frac{0\cdot 1156}{\cdot 6045} = 0\cdot 191 \text{ seconds.}$$

The height of $PN = \frac{1}{2} g\, TT'$—

$$= \frac{32\cdot 2 \times 3\cdot 259 \times 0\cdot 191}{2}$$

$$= 10\cdot 02 \text{ feet.}$$

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TABLE I.

A General Table of Values of $\frac{d^2}{w}T$ for Ogival-headed shot. $\left(\frac{d^2}{w}T = T_V - T_v\right)$.

v.	0	1	2	3	4	5	6	7	8	9	Diff.
f.s.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	+
10	75·399	77·111	78·790	80·437	82·052	83·636	85·190	86·715	88·212	89·682	1·584
11	91·125	92·542	93·934	95·301	96·644	97·964	99·261	*00·536	*01·789	*03·021	1·320
12	1 04·232	05·423	06·595	07·748	08·883	09·999	11·097	12·178	13·243	14·291	1·116
13	1 15·323	16·339	17·340	18·326	19·297	20·254	21·196	22·124	23·039	23·941	·957
14	24·830	25·706	26·570	27·422	28·262	29·091	29·908	30·714	31·509	32·294	·829
15	33·068	33·832	34·586	35·331	36·066	36·792	37·508	38·215	38·913	39·602	·726
16	1 40·283	40·955	41·618	42·273	42·920	43·559	44·190	44·813	45·429	46·038	·639
17	46·640	47·235	47·823	48·404	48·978	49·546	50·107	50·662	51·211	51·754	·568
18	52·291	52·822	53·347	53·867	54·381	54·890	55·393	55·890	56·382	56·869	·509
19	1 57·351	57·828	58·300	58·767	59·229	59·686	60·138	60·586	61·029	61·468	·457
20	61·902	62·332	62·758	63·180	63·598	64·012	64·422	64·828	65·230	65·628	·414
21	66·022	66·412	66·798	67·181	67·560	67·936	68·308	68·676	69·041	69·403	·376
22	1 69·762	70·118	70·470	70·819	71·165	71·508	71·848	72·185	72·519	72·850	·343
23	73·179	73·505	73·828	74·148	74·465	74·780	75·092	75·401	75·708	76·012	·315
24	76·314	76·613	76·909	77·203	77·494	77·783	78·070	78·354	78·636	78·916	·289
25	1 79·194	79·470	79·743	80·014	80·283	80·550	80·815	81·078	81·339	81·598	·267
26	81·855	82·110	82·363	82·614	82·863	83·110	83·355	83·598	83·839	84·079	·247
27	84·317	84·553	84·787	85·020	85·251	85·481	85·709	85·935	86·160	86·382	·230
28	1 86·604	86·824	87·042	87·259	87·474	87·688	87·900	88·111	88·320	88·528	·214
29	88·734	88·939	89·143	89·345	89·546	89·745	89·943	90·140	90·335	90·529	·199
30	90·721	90·912	91·102	91·291	91·478	91·664	91·849	92·033	92·216	92·397	·186
31	1 92·577	92·756	92·934	93·111	93·287	93·461	93·634	93·806	93·971	94·147	·174
32	94·316	94·484	94·651	94·817	94·982	95·146	95·309	95·471	95·632	95·792	·164
33	95·951	96·109	96·266	96·422	96·577	96·731	96·884	97·036	97·187	97·338	·154
34	1 97·488	97·637	97·785	97·932	98·078	98·223	98·367	98·510	98·652	98·794	·145
35	98·935	99·075	99·214	99·352	99·490	99·627	99·763	99·898	*00·032	*00·166	·137
36	2 00·299	00·431	00·562	00·692	00·822	00·951	01·079	01·206	01·333	01·459	·129
37	2 01·585	01·710	01·834	01·957	02·080	02·202	02·323	02·443	02·563	02·682	·122
38	02·801	02·919	03·036	03·152	03·268	03·383	03·497	03·610	03·723	03·835	·115
39	03·947	04·058	04·168	04·278	04·387	04·496	04·604	04·711	04·818	04·924	·109
40	20 5·0299	5·1319	5·2393	5·3432	5·4466	5·5494	5·6517	5·7534	5·8546	5·9553	·1028
41	6·0554	6·1550	6·2540	6·3525	6·4505	6·5480	6·6450	6·7414	6·8373	6·9327	·0975
42	7·0276	7·1220	7·2159	7·3093	7·4022	7·4947	7·5867	7·6782	7·7693	7·8599	·0925
43	20 7·9501	8·0398	8·1291	8·2179	8·3063	8·3942	8·4817	8·5687	8·6553	8·7415	·0879
44	8·8272	8·9125	8·9974	9·0819	9·1660	9·2497	9·3330	9·4159	9·4984	9·5805	·0837
45	9·6622	9·7435	9·8244	9·9050	9·9852	*0·0651	*0·1446	*0·2237	*0·3025	*0·3809	·0799
46	21 0·1590	0·5367	0·6140	0·6910	0·7677	0·8440	0·9200	0·9956	1·0709	1·1459	·0763
47	1·2205	1·2948	1·3687	1·4423	1·5156	1·5886	1·6613	1·7336	1·8056	1·8773	·0730
48	1·9187	2·0198	2·0906	2·1611	2·2313	2·3012	2·3708	2·4401	2·5091	2·5779	·0699
49	21 2·6464	2·7146	2·7825	2·8501	2·9174	2·9845	3·0513	3·1178	3·1841	3·2501	·0671
50	3·3159	3·3814	3·4466	3·5116	3·5763	3·6608	3·7050	3·7689	3·8326	3·8960	·0645
51	3·9592	4·0221	4·0848	4·1472	4·2094	4·2713	4·3330	4·3944	4·4556	4·5165	·0619
52	21 4·5772	4·6377	4·6979	4·7579	4·8177	4·8773	4·9367	4·9958	5·0547	5·1134	·0596
53	5·1719	5·2302	5·2882	5·3460	5·4036	5·4610	5·5182	5·5752	5·6320	5·6886	·0574
54	5·7450	5·8012	5·8572	5·9130	5·9686	6·0240	6·0792	6·1342	6·1890	6·2436	·0554
55	21 6·2980	6·3522	6·4062	6·4600	6·5136	6·5670	6·6202	6·6732	6·7260	6·7786	·0534
56	6·8311	6·8834	6·9355	6·9874	7·0391	7·0907	7·1421	7·1933	7·2444	7·2953	·0516
57	7·3460	7·3965	7·4469	7·4971	7·5471	7·5970	7·6467	7·6962	7·7456	7·7948	·0499
58	21 7·8438	7·8928	7·9417	7·9904	8·0389	8·0873	8·1356	8·1837	8·2316	8·2793	·0483
59	8·3271	8·3746	8·4220	8·4692	8·5163	8·5632	8·6100	8·6566	8·7031	8·7494	·0468
60	8·7957	8·8417	8·8877	8·9334	8·9791	9·0246	9·0700	9·1152	9·1603	9·2052	·0454
61	21 9·2501	9·2947	9·3393	9·3837	9·4280	9·4721	9·5161	9·5600	9·6037	9·6473	·0441
62	9·6908	9·7341	9·7773	9·8204	9·8633	9·9062	9·9489	9·9914	*0·0338	*0·0761	·0428
63	22 0·1183	0·1604	0·2023	0·2441	0·2858	0·3273	0·3687	0·4100	0·4512	0·4922	·0415
64	22 0·5332	0·5740	0·6147	0·6552	0·6957	0·7360	0·7762	0·8163	0·8563	0·8962	·0403
65	0·9359	0·9755	1·0151	1·0544	1·0937	1·1328	1·1718	1·2107	1·2495	1·2881	·0391
66	1·3267	1·3651	1·4034	1·4416	1·4797	1·5177	1·5555	1·5933	1·6309	1·6684	·0379

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TABLE I.—*continued.*

A General Table of Values of $\frac{d^2}{w}T$ for Ogival-headed shot. $\left(\frac{d^2}{w}T = T_V - T_v\right)$.

v.	0	1	2	3	4	5	6	7	8	9	Diff.
f.s.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	+
67	22 1·7059	1·7432	1·7804	1·8175	1·8545	1·8914	1·9281	1·9648	2·0014	2·0378	·0368
68	2·0742	2·1105	2·1466	2·1827	2·2186	2·2545	2·2902	2·3259	2·3614	2·3969	·0358
69	2·4322	2·4675	2·5027	2·5377	2·5727	2·6076	2·6424	2·6771	2·7117	2·7462	·0348
70	22 2·7806	2·8150	2·8492	2·8833	2·9174	2·9513	2·9852	3·0189	3·0526	3·0862	·0339
71	3·1196	3·1530	3·1863	3·2195	3·2526	3·2856	3·3185	3·3513	3·3840	3·4167	·0330
72	3·4492	3·4816	3·5140	3·5462	3·5784	3·6105	3·6424	3·6743	3·7061	3·7378	·0320
73	22 3·7694	3·8009	3·8323	3·8636	3·8949	3·9260	3·9571	3·9881	4·0189	4·0497	·0311
74	4·0804	4·1110	4·1416	4·1720	4·2024	4·2326	4·2628	4·2929	4·3230	4·3529	·0302
75	4·3828	4·4125	4·4422	4·4719	4·5014	4·5308	4·5602	4·5895	4·6187	4·6478	·0294
76	22 4·6769	4·7058	4·7347	4·7635	4·7922	4·8208	4·8493	4·8777	4·9060	4·9343	·0286
77	4·9624	4·9905	5·0185	5·0464	5·0742	5·1020	5·1296	5·1572	5·1847	5·2121	·0277
78	5·2394	5·2666	5·2937	5·3208	5·3478	5·3747	5·4015	5·4282	5·4549	5·4814	·0268
79	22 5·5079	5·5343	5·5606	5·5869	5·6130	5·6391	5·6652	5·6911	5·7170	5·7428	·0261
80	5·7685	5·7941	5·8197	5·8452	5·8706	5·8959	5·9212	5·9463	5·9714	5·9965	·0253
81	6·0214	6·0463	6·0711	6·0959	6·1205	6·1451	6·1696	6·1941	6·2184	6·2427	·0245
82	22 6·2669	6·2910	6·3151	6·3390	6·3629	6·3867	6·4104	6·4340	6·4576	6·4810	·0237
83	6·5044	6·5277	6·5509	6·5740	6·5971	6·6201	6·6430	6·6658	6·6885	6·7111	·0229
84	6·7337	6·7562	6·7786	6·8009	6·8232	6·8454	6·8675	6·8895	6·9114	6·9333	·0221
85	22 6·9551	6·9768	6·9984	7·0200	7·0415	7·0629	7·0842	7·1055	7·1267	7·1478	·0214
86	7·1688	7·1898	7·2107	7·2315	7·2522	7·2729	7·2935	7·3140	7·3345	7·3549	·0206
87	7·3752	7·3954	7·4156	7·4357	7·4558	7·4757	7·4956	7·5155	7·5353	7·5550	·0199
88	22 7·5746	7·5942	7·6137	7·6332	7·6526	7·6719	7·6912	7·7104	7·7295	7·7486	·0193
89	7·7677	7·7866	7·8055	7·8244	7·8431	7·8618	7·8805	7·8991	7·9176	7·9360	·0187
90	7·9544	7·9727	7·9909	8·0091	8·0272	8·0452	8·0632	8·0812	8·0990	8·1168	·0180
91	22 8·1346	8·1523	8·1699	8·1875	8·2050	8·2225	8·2399	8·2573	8·2746	8·2918	·0174
92	8·3090	8·3261	8·3432	8·3602	8·3772	8·3941	8·4109	8·4277	8·4445	8·4611	·0169
93	8·4778	8·4943	8·5109	8·5273	8·5437	8·5601	8·5764	8·5927	8·6089	8·6250	·0163
94	22 8·6411	8·6572	8·6732	8·6892	8·7051	8·7209	8·7367	8·7525	8·7682	8·7838	·0158
95	8·7994	8·8150	8·8305	8·8459	8·8613	8·8767	8·8920	8·9073	8·9225	8·9376	·0153
96	8·9528	8·9678	8·9828	8·9978	9·0123	9·0276	9·0425	9·0573	9·0720	9·0867	·0149
97	22 9·1014	9·1160	9·1306	9·1451	9·1595	9·1740	9·1884	9·2027	9·2170	9·2312	·0144
98	9·2454	9·2596	9·2737	9·2878	9·3018	9·3158	9·3298	9·3437	9·3575	9·3713	·0140
99	9·3851	9·3989	9·4126	9·4262	9·4398	9·4534	9·4670	9·4805	9·4939	9·5073	·0136
100	22 9·5207	9·5340	9·5473	9·5606	9·5738	9·5869	9·6001	9·6132	9·6262	9·6392	·0132
101	9·6522	9·6651	9·6780	9·6908	9·7036	9·7164	9·7291	9·7418	9·7544	9·7670	·0127
102	9·7796	9·7921	9·8046	9·8170	9·8294	9·8417	9·8540	9·8662	9·8783	9·8904	·0123
103	22 9·9024	9·9144	9·9262	9·9380	9·9496	9·9612	9·9727	9·9841	9·9954	*0·0066	·0115
104	23 0·0177	0·0287	0·0396	0·0504	0·0610	0·0716	0·0820	0·0923	0·1025	0·1126	·0105
105	0·1226	0·1325	0·1423	0·1520	0·1615	0·1710	0·1804	0·1897	0·1988	0·2079	·0094
106	23 0·2170	0·2259	0·2347	0·2435	0·2522	0·2609	0·2694	0·2780	0·2864	0·2948	·0086
107	0·3031	0·3114	0·3196	0·3278	0·3359	0·3439	0·3520	0·3599	0·3678	0·3757	·0080
108	0·3835	0·3913	0·3990	0·4067	0·4143	0·4219	0·4295	0·4370	0·4445	0·4519	·0076
109	23 0·4593	0·4667	0·4740	0·4813	0·4885	0·4958	0·5030	0·5101	0·5172	0·5243	·0072
110	0·5314	0·5384	0·5454	0·5524	0·5593	0·5662	0·5731	0·5800	0·5868	0·5936	·0069
111	0·6004	0·6071	0·6139	0·6206	0·6272	0·6339	0·6405	0·6471	0·6537	0·6603	·0066
112	23 0·6668	0·6733	0·6798	0·6863	0·6928	0·6992	0·7056	0·7120	0·7184	0·7248	·0064
113	0·7311	0·7374	0·7437	0·7500	0·7563	0·7625	0·7688	0·7750	0·7812	0·7874	·0062
114	0·7936	0·7997	0·8059	0·8120	0·8181	0·8242	0·8303	0·8364	0·8424	0·8484	·0061
115	23 0·8545	0·8605	0·8665	0·8726	0·8787	0·8847	0·8906	0·8965	0·9024	0·9083	·0059
116	0·9142	0·9200	0·9259	0·9317	0·9375	0·9433	0·9490	0·9548	0·9605	0·9663	·0058
117	0·9720	0·9777	0·9833	0·9890	0·9947	1·0003	1·0059	1·0115	1·0171	1·0227	·0056
118	23 1·0283	1·0338	1·0394	1·0449	1·0504	1·0559	1·0614	1·0669	1·0723	1·0778	·0055
119	1·0832	1·0886	1·0940	1·0994	1·1048	1·1101	1·1154	1·1208	1·1261	1·1314	·0054
120	1·1367	1·1420	1·1473	1·1525	1·1578	1·1630	1·1682	1·1734	1·1786	1·1838	·0052
121	23 1·1889	1·1941	1·1992	1·2043	1·2095	1·2146	1·2196	1·2247	1·2298	1·2348	·0051
122	1·2399	1·2449	1·2499	1·2549	1·2599	1·2649	1·2698	1·2748	1·2797	1·2847	·0050
123	1·2896	1·2945	1·2994	1·3043	1·3091	1·3140	1·3188	1·3237	1·3285	1·3333	·0049

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TABLE I.—*continued.*

A General Table of Values of $\frac{d^2}{w}T$ for Ogival-headed shot. $\left(\frac{d^2}{w}T = T_V - T_v\right)$.

v.	0	1	2	3	4	5	6	7	8	9	Diff.
f.s.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	+
124	23 1·3381	1·3429	1·3477	1·3524	1·3572	1·3619	1·3667	1·3714	1·3761	1·3808	·0047
125	1·3855	1·3902	1·3948	1·3995	1·4041	1·4088	1·4134	1·4180	1·4226	1·4272	·0046
126	1·4318	1·4364	1·4410	1·4455	1·4501	1·4546	1·4591	1·4636	1·4681	1·4726	·0045
127	23 1·4771	1·4816	1·4860	1·4905	1·4949	1·4993	1·5038	1·5082	1·5126	1·5170	·0044
128	1·5214	1·5257	1·5301	1·5345	1·5388	1·5431	1·5475	1·5518	1·5561	1·5604	·0043
129	1·5647	1·5690	1·5732	1·5775	1·5818	1·5860	1·5902	1·5945	1·5987	1·6029	·0042
130	23 1·6071	1·6113	1·6155	1·6196	1·6238	1·6280	1·6321	1·6362	1·6404	1·6445	·0042
131	1·6486	1·6527	1·6568	1·6609	1·6650	1·6690	1·6731	1·6772	1·6812	1·6852	·0041
132	1·6893	1·6933	1·6973	1·7013	1·7053	1·7093	1·7133	1·7173	1·7212	1·7252	·0040
133	23 1·7291	1·7331	1·7370	1·7410	1·7449	1·7488	1·7527	1·7566	1·7605	1·7644	·0039
134	1·7682	1·7721	1·7760	1·7798	1·7837	1·7875	1·7913	1·7952	1·7990	1·8028	·0038
135	1·8066	1·8104	1·8142	1·8179	1·8217	1·8255	1·8292	1·8330	1·8367	1·8405	·0038
136	23 1·8442	1·8479	1·8517	1·8554	1·8591	1·8628	1·8665	1·8702	1·8738	1·8775	·0037
137	1·8812	1·8848	1·8885	1·8921	1·8958	1·8994	1·9030	1·9067	1·9103	1·9139	·0036
138	1·9175	1·9211	1·9247	1·9282	1·9318	1·9354	1·9390	1·9425	1·9461	1·9496	·0036
139	23 1·9532	1·9567	1·9602	1·9638	1·9673	1·9708	1·9743	1·9778	1·9813	1·9848	·0035
140	1·9883	1·9918	1·9952	1·9987	2·0022	2·0056	2·0091	2·0125	2·0160	2·0194	·0035
141	2·0228	2·0263	2·0297	2·0331	2·0365	2·0399	2·0433	2·0467	2·0501	2·0535	·0034
142	23 2·0569	2·0602	2·0636	2·0670	2·0703	2·0737	2·0770	2·0804	2·0837	2·0870	·0034
143	2·0904	2·0937	2·0970	2·1003	2·1036	2·1069	2·1102	2·1135	2·1168	2·1201	·0033
144	2·1234	2·1267	2·1299	2·1332	2·1364	2·1397	2·1430	2·1462	2·1494	2·1527	·0033
145	23 2·1559	2·1591	2·1624	2·1656	2·1688	2·1720	2·1752	2·1784	2·1816	2·1848	·0032
146	2·1880	2·1912	2·1944	2·1975	2·2007	2·2039	2·2071	2·2102	2·2134	2·2165	·0032
147	2·2197	2·2228	2·2260	2·2291	2·2322	2·2354	2·2385	2·2416	2·2447	2·2478	·0031
148	23 2·2509	2·2540	2·2571	2·2602	2·2633	2·2664	2·2695	2·2726	2·2757	2·2787	·0031
149	2·2818	2·2849	2·2879	2·2910	2·2940	2·2971	2·3001	2·3032	2·3062	2·3093	·0030
150	2·3123	2·3153	2·3183	2·3214	2·3244	2·3274	2·3304	2·3334	2·3364	2·3394	·0030
151	23 2·3424	2·3454	2·3484	2·3514	2·3543	2·3573	2·3603	2·3633	2·3662	2·3692	·0030
152	2·3722	2·3751	2·3781	2·3810	2·3840	2·3869	2·3899	2·3928	2·3958	2·3987	·0029
153	2·4016	2·4046	2·4075	2·4104	2·4133	2·4162	2·4192	2·4221	2·4250	2·4279	·0029
154	23 2·4308	2·4337	2·4366	2·4395	2·4424	2·4453	2·4481	2·4510	2·4539	2·4568	·0029
155	2·4597	2·4625	2·4654	2·4683	2·4711	2·4740	2·4768	2·4797	2·4825	2·4854	·0029
156	2·4882	2·4911	2·4939	2·4967	2·4996	2·5024	2·5052	2·5080	2·5108	2·5137	·0028
157	23 2·5165	2·5193	2·5221	2·5249	2·5277	2·5305	2·5333	2·5361	2·5389	2·5416	·0028
158	2·5444	2·5472	2·5500	2·5528	2·5555	2·5583	2·5611	2·5638	2·5666	2·5693	·0028
159	2·5721	2·5748	2·5776	2·5803	2·5831	2·5858	2·5885	2·5913	2·5940	2·5967	·0027
160	23 2·5994	2·6022	2·6049	2·6076	2·6103	2·6130	2·6157	2·6184	2·6211	2·6238	·0027
161	2·6265	2·6292	2·6319	2·6346	2·6373	2·6400	2·6426	2·6453	2·6480	2·6506	·0027
162	2·6533	2·6560	2·6586	2·6613	2·6640	2·6666	2·6693	2·6719	2·6745	2·6772	·0026
163	23 2·6798	2·6825	2·6851	2·6877	2·6903	2·6930	2·6956	2·6982	2·7008	2·7034	·0026
164	2·7061	2·7087	2·7113	2·7139	2·7165	2·7191	2·7217	2·7243	2·7268	2·7294	·0026
165	2·7320	2·7346	2·7372	2·7398	2·7423	2·7449	2·7475	2·7500	2·7526	2·7552	·0026
166	23 2·7577	2·7603	2·7628	2·7654	2·7679	2·7705	2·7730	2·7756	2·7781	2·7806	·0025
167	2·7832	2·7857	2·7882	2·7908	2·7933	2·7958	2·7983	2·8008	2·8034	2·8059	·0025
168	2·8084	2·8109	2·8134	2·8159	2·8184	2·8209	2·8234	2·8258	2·8283	2·8308	·0025
169	23 2·8333	2·8358	2·8383	2·8407	2·8432	2·8457	2·8481	2·8506	2·8531	2·8555	·0025
170	2·8580	2·8604	2·8629	2·8653	2·8678	2·8702	2·8726	2·8751	2·8775	2·8799	·0024
171	2·8824	2·8848	2·8872	2·8896	2·8921	2·8945	2·8969	2·8993	2·9017	2·9041	·0024
172	23 2·9065	2·9089	2·9113	2·9137	2·9161	2·9185	2·9209	2·9233	2·9257	2·9281	·0024
173	2·9304	2·9328	2·9352	2·9376	2·9399	2·9423	2·9447	2·9470	2·9494	2·9518	·0024
174	2·9541	2·9565	2·9588	2·9612	2·9635	2·9659	2·9682	2·9705	2·9729	2·9752	·0023
175	23 2·9776	2·9799	2·9822	2·9845	2·9869	2·9892	2·9915	2·9938	2·9961	2·9985	·0023
176	3·0008	3·0031	3·0054	3·0077	3·0100	3·0123	3·0146	3·0169	3·0192	3·0215	·0023
177	3·0237	3·0260	3·0283	3·0306	3·0329	3·0351	3·0374	3·0397	3·0420	3·0442	·0023
178	23 3·0465	3·0488	3·0510	3·0533	3·0555	3·0578	3·0600	3·0623	3·0645	3·0668	·0023
179	3·0690	3·0713	3·0735	3·0757	3·0780	3·0802	3·0824	3·0847	3·0869	3·0891	·0022
180	3·0913	3·0935	3·0958	3·0980	3·1002	3·1024	3·1045	3·1068	3·1090	3·1112	·0022

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TABLE I.—*continued.*

A General Table of Values of $\frac{d^2}{w}T$ for Ogival-headed shot. $\left(\frac{d^2}{w}T = T_V - T_v\right)$.

v.	0	1	2	3	4	5	6	7	8	9	Diff.
f.s.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	+
181	23 3·1134	3·1156	3·1178	3·1200	3·1222	3·1244	3·1266	3·1287	3·1309	3·1331	·0022
182	3·1353	3·1375	3·1396	3·1418	3·1440	3·1461	3·1483	3·1505	3·1526	3·1548	·0022
183	3·1569	3·1591	3·1613	3·1634	3·1656	3·1677	3·1698	3·1720	3·1741	3·1763	·0021
184	23 3·1784	3·1805	3·1827	3·1848	3·1869	3·1891	3·1912	3·1933	3·1954	3·1975	·0021
185	3·1997	3·2018	3·2039	3·2060	3·2081	3·2102	3·2123	3·2144	3·2165	3·2186	·0021
186	3·2207	3·2228	3·2249	3·2270	3·2291	3·2312	3·2333	3·2353	3·2374	3·2395	·0021
187	23 3·2416	3·2437	3·2457	3·2478	3·2499	3·2520	3·2540	3·2561	3·2582	3·2602	·0021
188	3·2623	3·2643	3·2664	3·2685	3·2705	3·2726	3·2746	3·2767	3·2787	3·2808	·0021
189	3·2828	3·2848	3·2869	3·2889	3·2909	3·2930	3·2950	3·2970	3·2991	3·3011	·0020
190	23 3·3031	3·3051	3·3072	3·3092	3·3112	3·3132	3·3152	3·3172	3·3192	3·3212	·0020
191	3·3233	3·3253	3·3273	3·3293	3·3313	3·3333	3·3353	3·3372	3·3392	3·3412	·0020
192	3·3432	3·3452	3·3472	3·3492	3·3511	3·3531	3·3551	3·3571	3·3590	3·3610	·0020
193	23 3·3630	3·3649	3·3669	3·3689	3·3708	3·3728	3·3747	3·3767	3·3786	3·3806	·0020
194	3·3825	3·3845	3·3864	3·3884	3·3903	3·3922	3·3942	3·3961	3·3980	3·4000	·0019
195	3·4019	3·4038	3·4057	3·4077	3·4096	3·4115	3·4134	3·4153	3·4172	3·4192	·0019
196	23 3·4211	3·4230	3·4249	3·4268	3·4287	3·4306	3·4325	3·4344	3·4362	3·4381	·0019
197	3·4400	3·4419	3·4438	3·4457	3·4476	3·4494	3·4513	3·4532	3·4550	3·4569	·0019
198	3·4588	3·4606	3·4625	3·4644	3·4662	3·4681	3·4699	3·4718	3·4736	3·4755	·0019
199	23 3·4773	3·4791	3·4810	3·4828	3·4846	3·4865	3·4883	3·4901	3·4920	3·4938	·0018
200	3·4956	3·4974	3·4992	3·5010	3·5028	3·5047	3·5065	3·5083	3·5101	3·5119	·0018
201	3·5137	3·5155	3·5172	3·5190	3·5208	3·5226	3·5244	3·5262	3·5280	3·5297	·0018
202	23 3·5315	3·5333	3·5351	3·5368	3·5386	3·5404	3·5421	3·5439	3·5456	3·5474	·0018
203	3·5492	3·5509	3·5527	3·5544	3·5561	3·5579	3·5596	3·5614	3·5631	3·5648	·0017
204	3·5666	3·5683	3·5700	3·5717	3·5735	3·5752	3·5769	3·5786	3·5803	3·5820	·0017
205	23 3·5837	3·5854	3·5871	3·5888	3·5905	3·5922	3·5939	3·5956	3·5973	3·5990	·0017
206	3·6007	3·6024	3·6040	3·6057	3·6074	3·6091	3·6107	3·6124	3·6141	3·6157	·0017
207	3·6174	3·6191	3·6207	3·6224	3·6240	3·6257	3·6273	3·6290	3·6306	3·6323	·0016
208	23 3·6339	3·6355	3·6372	3·6388	3·6404	3·6420	3·6437	3·6453	3·6469	3·6485	·0016
209	3·6502	3·6518	3·6534	3·6550	3·6566	3·6582	3·6598	3·6614	3·6630	3·6646	·0016
210	3·6662	3·6678	3·6694	3·6710	3·6726	3·6741	3·6757	3·6773	3·6789	3·6805	·0016
211	23 3·6820	3·6836	3·6852	3·6867	3·6883	3·6899	3·6914	3·6930	3·6946	3·6961	·0016
212	3·6977	3·6992	3·7008	3·7023	3·7039	3·7054	3·7070	3·7085	3·7100	3·7116	·0015
213	3·7131	3·7146	3·7162	3·7177	3·7192	3·7207	3·7223	3·7238	3·7253	3·7268	·0015
214	23 3·7283	3·7298	3·7313	3·7329	3·7344	3·7359	3·7374	3·7389	3·7404	3·7419	·0015
215	3·7434	3·7448	3·7463	3·7478	3·7493	3·7508	3·7523	3·7538	3·7552	3·7567	·0015
216	3·7582	3·7597	3·7612	3·7626	3·7641	3·7656	3·7670	3·7685	3·7700	3·7714	·0015
217	23 3·7729	3·7743	3·7758	3·7772	3·7787	3·7801	3·7816	3·7830	3·7845	3·7859	·0014
218	3·7874	3·7888	3·7902	3·7917	3·7931	3·7945	3·7960	3·7974	3·7988	3·8002	·0014
219	3·8016	3·8031	3·8045	3·8059	3·8073	2·8087	3·8101	3·8115	3·8129	3·8144	·0014
220	23 3·8158	3·8172	3·8186	3·8200	3·8214	3·8227	3·8241	3·8255	3·8269	3·8283	·0014
221	3·8297	3·8311	3·8325	3·8338	3·8352	3·8366	3·8380	3·8394	3·8407	3·8421	·0014
222	3·8435	3·8448	3·8462	3·8476	3·8489	3·8503	3·8517	3·8530	3·8544	3·8557	·0014
223	23 3·8571	3·8584	3·8598	3·8611	3·8625	3·8638	3·8651	3·8665	3·8678	3·8692	·0013
224	3·8705	3·8718	3·8732	3·8745	3·8758	3·8772	3·8785	3·8798	3·8811	3·8824	·0013
225	3·8838	3·8851	3·8864	3·8877	3·8890	3·8903	3·8916	3·8930	3·8943	3·8956	·0013
226	23 3·8969	3·8982	3·8995	3·9008	3·9021	3·9034	3·9047	3·9059	3·9072	3·9085	·0013
227	3·9098	3·9111	3·9124	3·9137	3·9150	3·9162	3·9175	3·9188	3·9201	3·9214	·0013
228	3·9226	3·9239	3·9252	3·9264	3·9277	3·9290	3·9303	3·9315	3·9328	3·9341	·0013
229	23 3·9353	3·9366	3·9378	3·9391	3·9404	3·9416	3·9429	3·9441	3·9454	3·9467	·0013
230	3·9479	3·9492	3·9504	3·9517	3·9529	3·9542	3·9554	3·9567	3·9579	3·9592	·0013
231	3·9604	3·9617	3·9629	3·9642	3·9654	3·9667	3·9679	3·9692	3·9704	3·9716	·0012
232	23 3·9729	3·9741	3·9754	3·9766	3·9779	3·9791	3·9803	3·9816	3·9828	3·9841	·0012
233	3·9853	3·9866	3·9878	3·9890	3·9903	3·9915	3·9927	3·9940	3·9952	3·9965	·0012
234	3·9977	3·9989	4·0002	4·0014	4·0026	4·0039	4·0051	4·0063	4·0076	4·0088	·0012
235	23 4·0100	4·0113	4·0125	4·0137	4·0150	4·0162	4·0174	4·0186	4·0199	4·0211	·0012
236	4·0223	4·0236	4·0248	4·0260	4·0272	4·0284	4·0297	4·0309	4·0321	4·0334	·0012
237	4·0346	4·0358	4·0370	4·0383	4·0395	4·0407	4·0419	4·0431	4·0444	4·0456	·0012

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TABLE I.—*continued.*

A General Table of Values of $\frac{d^2}{v}T$ for Ogival-headed shot. $\left(\frac{d^2}{v}T = T_V - T_v\right)$.

v.	0	1	2	3	4	5	6	7	8	9	Diff.
f.s.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	secs.	+
238	23 4·0468	4·0480	4·0492	4·0505	4·0517	4·0529	4·0541	4·0553	4·0566	4·0578	·0012
239	4·0590	4·0602	4·0614	4·0626	4·0639	4·0651	4·0663	4·0675	4·0687	4·0699	·0012
240	4·0711	4·0724	4·0736	4·0748	4·0760	4·0772	4·0784	4·0796	4·0809	4·0821	·0012
241	23 4·0833	4·0845	4·0857	4·0869	4·0881	4·0893	4·0905	4·0917	4·0930	4·0942	·0012
242	4·0954	4·0966	4·0978	4·0990	4·1002	4·1014	4·1026	4·1038	4·1050	4·1062	·0012
243	4·1074	4·1087	4·1099	4·1111	4·1123	4·1135	4·1147	4·1159	4·1171	4·1183	·0012
241	23 4·1195	4·1207	4·1219	4·1231	4·1243	4·1255	4·1267	4·1279	4·1291	4·1303	·0012
245	4·1315	4·1327	4·1339	4·1351	4·1363	4·1375	4·1387	4·1399	4·1411	4·1423	·0012
246	4·1435	4·1447	4·1459	4·1471	4·1483	4·1495	4·1506	4·1518	4·1530	4·1542	·0012
247	23 4·1554	4·1566	4·1578	4·1590	4·1602	4·1614	4·1626	4·1638	4·1649	4·1661	·0012
248	4·1673	4·1685	4·1697	4·1709	4·1721	4·1733	4·1744	4·1756	4·1768	4·1780	·0012
249	4·1792	4·1804	4·1815	4·1827	4·1839	4·1851	4·1863	4·1874	4·1886	4·1898	·0012
250	23 4·1910	4·1922	4·1933	4·1945	4·1957	4·1969	4·1980	4·1992	4·2004	4·2015	·0012
251	4·2027	4·2039	4·2051	4·2062	4·2074	4·2086	4·2097	4·2109	4·2121	4·2132	·0012
252	4·2144	4·2156	4·2167	4·2179	4·2190	4·2202	4·2214	4·2225	4·2237	4·2248	·0012
253	23 4·2260	4·2272	4·2283	4·2295	4·2306	4·2318	4·2329	4·2341	4·2352	4·2364	·0012
254	4·2375	4·2387	4·2398	4·2410	4·2421	4·2433	4·2444	4·2455	4·2467	4·2478	·0011
255	4·2490	4·2501	4·2513	4·2524	4·2535	4·2547	4·2558	4·2569	4·2581	4·2592	·0011
256	23 4·2603	4·2615	4·2626	4·2637	4·2648	4·2660	4·2671	4·2682	4·2693	4·2705	·0011
257	4·2716	4·2727	4·2738	4·2749	4·2760	4·2772	4·2783	4·2794	4·2805	4·2816	·0011
258	4·2827	4·2838	4·2849	4·2860	4·2871	4·2882	4·2893	4·2904	4·2915	4·2926	·0011
259	23 4·2937	4·2948	4·2959	4·2970	4·2981	4·2992	4·3003	4·3014	4·3025	4·3036	·0011
260	4·3046	4·3057	4·3068	4·3079	4·3090	4·3101	4·3111	4·3122	4·3133	4·3144	·0011
261	4·3154	4·3165	4·3176	4·3187	4·3197	4·3208	4·3219	4·3229	4·3240	4·3250	·0011
262	23 4·3261	4·3272	4·3282	4·3293	4·3303	4·3314	4·3325	4·3335	4·3346	4·3356	·0011
263	4·3367	4·3377	4·3388	4·3398	4·3409	4·3419	4·3429	4·3440	4·3450	4·3461	·0010
264	4·3471	4·3482	4·3492	4·3502	4·3513	4·3523	4·3533	4·3544	4·3554	4·3564	·0010
265	23 4·3574	4·3585	4·3595	4·3605	4·3615	4·3626	4·3636	4·3646	4·3656	4·3667	·0010
266	4·3677	4·3687	4·3697	4·3707	4·3717	4·3728	4·3738	4·3748	4·3758	4·3768	·0010
267	4·3778	4·3788	4·3798	4·3808	4·3818	4·3828	4·3838	4·3848	4·3858	4·3868	·0010
268	23 4·3878	4·3888	4·3898	4·3908	4·3918	4·3928	4·3938	4·3948	4·3958	4·3968	·0010
269	4·3977	4·3987	4·3997	4·4007	4·4017	4·4027	4·4036	4·4046	4·4056	4·4066	·0010
270	4·4075	4·4085	4·4095	4·4105	4·4114	4·4124	4·4134	4·4143	4·4153	4·4163	·0010
271	23 4·4172	4·4182	4·4192	4·4201	4·4211	4·4220	4·4230	4·4240	4·4249	4·4259	·0010
272	4·4268	4·4278	4·4287	4·4297	4·4307	4·4316	4·4326	4·4335	4·4344	4·4354	·0010
273	4·4363	4·4373	4·4382	4·4392	4·4401	4·4411	4·4420	4·4429	4·4439	4·4448	·0009
274	23 4·4457	4·4467	4·4476	4·4485	4·4495	4·4504	4·4513	4·4523	4·4532	4·4541	·0009
275	4·4551	4·4560	4·4569	4·4578	4·4587	4·4597	4·4606	4·4615	4·4624	4·4633	·0009
276	4·4643	4·4652	4·4661	4·4670	4·4679	4·4688	4·4697	4·4706	4·4715	4·4725	·0009
277	23 4·4734	4·4743	4·4752	4·4761	4·4770	4·4779	4·4788	4·4797	4·4806	4·4815	·0009
278	4·4824	4·4833	4·4842	4·4850	4·4859	4·4868	4·4877	4·4886	4·4895	4·4904	·0009
279	4·4913	4·4922	4·4930	4·4939	4·4948	4·4957	4·4966	4·4975	4·4983	4·4992	·0009
280	23 4·5001	4·5010	4·5018	4·5027	4·5036	4·5045	4·5053	4·5062	4·5071	4·5080	·0009
281	4·5088	4·5097	4·5105	4·5114	4·5123	4·5131	4·5140	4·5148	4·5157	4·5166	·0009
282	4·5174	4·5183	4·5191	4·5200	4·5208	4·5217	4·5226	4·5234	4·5243	4·5251	·0009
283	23 4·5260	4·5268	4·5277	4·5285	4·5293	4·5302	4·5310	4·5319	4·5327	4·5336	·0008
284	4·5344	4·5352	4·5361	4·5369	4·5378	4·5386	4·5394	4·5403	4·5411	4·5419	·0008
285	4·5427	4·5436	4·5444	4·5452	4·5461	4·5469	4·5477	4·5485	4·5494	4·5502	·0008
286	23 4·5510	4·5518	4·5527	4·5535	4·5543	4·5551	4·5559	4·5567	4·5576	4·5584	·0008
287	4·5592	4·5600	4·5608	4·5616	4·5624	4·5632	4·5641	4·5648	4·5657	4·5665	·0008
288	4·5673	4·5681	4·5689	4·5697	4·5705	4·5713	4·5721	4·5729	4·5737	4·5745	·0008
289	23 4·5753	4·5761	4·5769	4·5777	4·5785	4·5793	4·5800	4·5808	4·5816	4·5824	·0008
290	4·5832										

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TABLE II.

A General Table of Values of $\frac{d^2}{w} S$ for Ogival-headed shot. $\left(\frac{d^2}{w} S = S_V - S_v\right)$.

v.	0	1	2	3	4	5	6	7	8	9	Diff.
f.s.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	+
10	1066	1238	1409	1578	1745	1910	2074	2236	2397	2557	166
11	2715	2871	3026	3180	3333	3484	3633	3782	3929	4075	151
12	4220	4363	4506	4647	4787	4926	5064	5200	5336	5471	139
13	5604	5737	5866	5999	6129	6257	6385	6511	6637	6762	129
14	6886	7009	7132	7253	7373	7493	7612	7730	7847	7964	120
15	8079	8194	8309	8422	8535	8647	8758	8868	8978	9087	112
16	9196	9304	9411	9517	9623	9728	9833	9937	10040	10142	105
17	10244	10346	10447	10546	10645	10743	10841	10939	11037	11134	98
18	11230	11326	11421	11516	11610	11704	11797	11890	11982	12074	94
19	12165	12256	12346	12436	12525	12614	12702	12791	12878	12966	89
20	13052	13139	13224	13310	13395	13480	13564	13648	13731	13814	85
21	13896	13979	14060	14142	14223	14303	14384	14463	14543	14622	81
22	14701	14779	14857	14935	15013	15090	15167	15244	15319	15395	77
23	15470	15545	15620	15694	15768	15842	15916	15989	16061	16134	74
24	16206	16278	16350	16421	16492	16563	16633	16703	16773	16843	71
25	1 6912·1	6981·2	7050·0	7118·5	7186·7	7254·7	7322·4	7389·8	7457·0	7523·9	68·0
26	7590·6	7657·0	7723·2	7789·1	7854·7	7920·1	7985·3	8050·2	8114·8	8179·3	65·4
27	8243·5	8307·5	8371·2	8434·7	8498·0	8561·0	8623·9	8686·4	8748·8	8810·9	63·0
28	1 8872·8	8934·5	8996·0	9057·2	9118·3	9179·1	9239·7	9300·1	9360·3	9420·3	60·8
29	9480·0	9539·6	9598·9	9658·1	9717·0	9775·8	9834·3	9892·6	9950·8	*0008·7	58·7
30	2 0066·5	0124·0	0181·4	0238·5	0295·5	0352·3	0409·0	0465·4	0521·7	0577·7	56·8
31	2 0633·6	0689·3	0744·8	0800·1	0855·3	0910·2	0965·0	1019·6	1074·0	1128·3	55·0
32	1182·4	1236·3	1290·0	1343·5	1396·9	1450·2	1503·2	1556·1	1608·8	1661·4	53·2
33	1713·8	1766·0	1818·1	1870·0	1921·7	1973·3	2024·7	2076·0	2127·1	2178·1	51·6
34	2 2228·9	2279·6	2330·0	2380·4	2430·6	2480·6	2530·5	2580·2	2629·7	2679·1	50·0
35	2728·4	2777·5	2826·4	2875·2	2923·8	2972·3	3020·7	3068·8	3116·9	3164·7	48·5
36	3212·5	3260·1	3307·5	3354·8	3402·0	3449·0	3495·9	3542·6	3589·2	3635·6	47·0
37	2 3682·0	3728·1	3774·2	3820·0	3865·8	3911·4	3956·9	4002·2	4047·4	4092·5	45·6
38	4137·4	4182·2	4226·8	4271·4	4315·7	4360·0	4404·1	4448·1	4491·9	4535·7	44·3
39	4579·2	4622·7	4666·0	4709·2	4752·3	4795·2	4838·1	4880·8	4923·3	4965·7	42·9
40	2 5008·0	5050·2	5092·3	5134·2	5176·0	5217·6	5259·2	5300·6	5341·9	5383·0	41·7
41	5424·0	5464·9	5505·7	5546·4	5586·9	5627·3	5667·6	5707·8	5747·8	5787·8	40·4
42	5827·6	5867·3	5906·9	5946·4	5985·8	6025·0	6064·2	6103·3	6142·2	6181·0	39·3
43	2 6219·8	6258·4	6296·9	6335·3	6373·6	6411·8	6449·9	6487·9	6525·8	6563·6	38·2
44	6601·3	6638·9	6676·4	6713·7	6751·0	6788·2	6825·3	6862·3	6899·3	6936·1	37·2
45	6972·8	7009·4	7046·0	7082·4	7118·8	7155·0	7191·2	7227·3	7263·3	7299·2	36·3
46	2 7335·1	7370·8	7406·5	7442·1	7477·6	7513·0	7548·3	7583·6	7618·8	7653·9	35·4
47	7688·9	7723·8	7758·7	7793·5	7828·2	7862·8	7897·3	7931·8	7966·2	8000·5	34·6
48	8034·7	8068·9	8103·0	8137·0	8170·9	8204·8	8238·6	8272·3	8305·9	8339·5	33·9
49	2 8373·0	8406·5	8439·8	8473·1	8506·1	8539·5	8572·6	8605·6	8638·6	8671·5	33·2
50	8704·3	8737·1	8769·8	8802·4	8835·0	8867·5	8900·0	8932·3	8964·7	8996·9	32·5
51	9029·1	9061·2	9093·2	9125·2	9157·1	9189·0	9220·8	9252·5	9284·2	9315·8	31·9
52	2 9347·3	9378·8	8410·3	9441·6	9472·9	9504·2	9535·4	9566·5	9597·6	9628·7	31·3
53	9659·6	9690·6	9721·4	9752·2	9783·0	9813·7	9844·3	9874·9	9905·4	9935·9	30·7
54	9966·3	9996·7	*0027·0	*0057·3	*0087·5	*0117·7	*0147·8	*0177·8	*0207·8	*0237·8	30·2
55	3 0267·6	0297·5	0327·3	0357·0	0386·7	0416·3	0445·9	0475·4	0504·9	0534·3	29·6
56	0563·6	0592·9	0622·2	0651·4	0680·6	0709·7	0738·7	0767·7	0796·7	0825·6	29·1
57	0854·5	0883·3	0912·1	0940·9	0969·6	0998·2	1026·8	1055·4	1083·9	1112·4	28·6
58	3 1140·8	1169·2	1197·6	1226·6	1254·3	1282·5	1310·8	1339·0	1367·1	1395·2	28·3
59	1423·3	1451·3	1479·3	1507·3	1535·2	1563·0	1590·9	1618·7	1646·4	1674·2	27·9
60	1701·8	1729·5	1757·1	1784·6	1812·2	1839·6	1867·1	1894·5	1921·9	1949·2	27·5
61	3 1976·5	2003·7	2031·0	2058·1	2085·3	2112·4	2139·4	2166·4	2193·4	2220·4	27·1
62	2247·3	2274·2	2301·0	2327·8	2354·5	2381·3	2407·9	2434·6	2461·2	2487·7	26·7
63	2514·3	2540·8	2567·2	2593·6	2620·0	2646·3	2672·6	2698·9	2725·1	2751·3	26·3
64	3 2777·5	2803·6	2829·7	2855·7	2881·7	2907·7	2933·7	2959·6	2985·4	3011·2	26·0
65	3037·0	3062·8	3088·5	3114·2	3139·8	3165·4	3191·0	3216·5	3242·0	3267·4	25·6
66	3292·8	3318·2	3343·5	3368·8	3394·1	3419·3	3444·5	3469·6	3494·7	3519·8	25·2

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TABLE II.—*continued.*

A General Table of Values of $\frac{d^2}{w}S$ for Ogival-headed shot. $\left(\frac{d^2}{w}S = S_V - S_v\right)$.

v.	0	1	2	3	4	5	6	7	8	9	Diff.
f.s.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	+
67	3 3544·8	3569·8	3594·8	3619·8	3644·7	3669·5	3694·3	3719·1	3743·9	3768·6	24·8
68	3793·3	3818·0	3842·6	3867·2	3891·7	3916·2	3940·7	3965·2	3989·8	4014·0	24·5
69	4038·4	4062·7	4087·0	4111·3	4135·6	4159·8	4184·0	4208·1	4232·2	4256·3	24·2
70	3 4280·4	4304·5	4328·5	4352·4	4376·4	4400·3	4424·1	4448·0	4471·8	4495·5	23·9
71	4519·3	4543·0	4566·6	4590·2	4613·8	4637·4	4660·9	4684·4	4707·8	4731·3	23·5
72	4754·7	4777·9	4801·3	4824·6	4847·9	4871·1	4894·2	4917·4	4940·5	4963·6	23·2
73	3 4986·6	5009·6	5032·6	5055·5	5078·4	5101·3	5124·1	5146·9	5169·6	5192·4	22·8
74	5215·1	5237·7	5260·3	5282·9	5305·5	5328·0	5350·5	5373·0	5395·4	5417·8	22·5
75	5440·2	5462·5	5484·8	5507·1	5529·3	5551·5	5573·7	5595·8	5617·9	5640·0	22·2
76	3 5662·1	5684·1	5706·0	5728·0	5749·9	5771·7	5793·5	5815·3	5837·0	5858·7	21·8
77	5880·4	5902·0	5923·6	5945·1	5966·6	5988·1	6009·5	6030·9	6052·2	6073·6	21·5
78	6094·8	6116·1	6137·3	6158·4	6179·6	6200·7	6221·7	6242·7	6263·7	6284·6	21·1
79	3 6305·5	6326·4	6347·2	6368·0	6388·8	6409·5	6430·2	6450·8	6471·4	6492·0	20·7
80	6512·6	6533·1	6553·6	6574·0	6594·4	6614·8	6635·1	6655·4	6675·7	6695·9	20·4
81	6716·1	6736·3	6756·4	6776·5	6796·5	6816·5	6836·5	6856·4	6876·3	6896·1	20·0
82	3 6916·0	6935·7	6955·5	6975·1	6994·8	7014·4	7033·9	7053·4	7072·9	7092·3	19·6
83	7111·7	7131·0	7150·3	7169·6	7188·8	7207·9	7227·1	7246·1	7265·2	7284·1	19·1
84	7303·1	7322·0	7340·8	7359·6	7378·4	7397·1	7415·8	7434·4	7453·0	7471·5	18·7
85	3 7490·0	7508·5	7526·9	7545·3	7563·6	7581·8	7600·0	7618·2	7636·3	7654·4	18·2
86	7672·4	7690·5	7708·4	7726·4	7744·2	7762·0	7779·9	7797·6	7815·4	7833·0	17·8
87	7850·6	7868·2	7885·8	7903·3	7920·8	7938·2	7955·6	7973·0	7990·3	8007·6	17·4
88	3 8024·8	8042·0	8059·2	8076·3	8093·4	8110·4	8127·4	8144·4	8161·3	8178·2	17·0
89	8195·0	8211·9	8228·6	8245·4	8262·1	8278·7	8295·4	8312·0	8328·5	8345·0	16·6
90	8361·5	8377·9	8394·3	8410·7	8427·0	8443·3	8459·6	8475·8	8492·0	8508·2	16·3
91	3 8524·3	8540·4	8556·4	8572·4	8588·4	8604·3	8620·3	8636·1	8652·0	8667·8	15·9
92	8683·5	8699·3	8715·0	8730·7	8746·3	8761·9	8777·5	8793·0	8808·5	8824·0	15·6
93	8839·4	8854·8	8870·2	8885·5	8900·8	8916·1	8931·3	8946·5	8961·7	8976·8	15·3
94	3 8991·9	9007·0	9022·0	9037·0	9052·0	9066·9	9081·9	9096·7	9111·6	9126·4	15·0
95	9141·2	9156·0	9170·7	9185·4	9200·1	9214·7	9229·3	9243·9	9258·4	9272·9	14·6
96	9287·4	9301·9	9316·3	9330·7	9345·0	9359·4	9373·7	9387·9	9402·2	9416·4	14·3
97	3 9430·6	9444·7	9458·9	9473·0	9487·0	9501·1	9515·1	9529·1	9543·0	9557·0	14·0
98	9570·8	9584·7	9598·6	9612·4	9626·1	9639·9	9653·6	9667·3	9681·0	9694·6	13·7
99	9708·3	9721·9	9735·4	9749·0	9762·5	9775·9	9789·4	9802·8	9816·2	9829·6	13·5
100	3 9842·9	9856·3	9869·6	9882·9	9896·1	9909·3	9922·5	9935·3	9948·8	9961·9	13·2
101	9975·0	9988·1	*0001·1	*0014·1	*0027·1	*0040·0	*0052·9	*0065·8	*0078·7	*0091·5	12·9
102	4 0104·3	0117·1	0129·8	0142·5	0155·2	0167·8	0180·4	0192·9	0205·4	0217·8	12·6
103	4 0230·1	0242·4	0254·6	0266·8	0278·8	0290·8	0302·7	0314·5	0326·2	0337·8	11·9
104	0349·4	0360·8	0372·2	0383·4	0394·5	0405·6	0416·5	0427·3	0438·1	0448·7	11·0
105	0459·2	0469·6	0479·9	0490·0	0500·1	0510·1	0520·0	0529·8	0539·5	0549·2	9·9
106	4 0558·7	0568·2	0577·6	0586·9	0596·9	0605·1	0614·5	0623·6	0632·6	0641·6	9·2
107	0650·5	0659·3	0668·1	0676·9	0685·6	0694·2	0702·8	0711·4	0719·9	0728·4	8·6
108	0736·8	0745·2	0753·6	0761·9	0770·2	0778·4	0786·6	0794·8	0802·9	0811·0	8·2
109	4 0819·0	0827·1	0835·0	0843·0	0850·2	0858·9	0866·7	0874·6	0882·4	0890·2	7·9
110	0897·9	0905·7	0913·4	0921·1	0928·7	0936·4	0944·0	0951·5	0959·1	0966·6	7·6
111	0974·2	0981·6	0989·1	0996·6	1004·0	1011·4	1018·8	1026·2	1033·5	1040·9	7·4
112	4 1048·2	1055·5	1062·8	1070·0	1077·3	1084·5	1091·7	1099·0	1106·1	1113·3	7·2
113	1120·5	1127·6	1134·8	1141·9	1149·0	1156·1	1163·2	1170·2	1177·3	1184·4	7·1
114	1191·4	1198·4	1205·4	1212·4	1219·4	1226·4	1233·3	1240·3	1247·2	1254·1	6·9
115	4 1261·0	1267·9	1274·8	1281·7	1288·6	1295·4	1302·3	1309·1	1315·9	1322·7	6·8
116	1329·5	1336·3	1343·1	1349·8	1356·6	1363·3	1370·0	1376·7	1383·4	1390·1	6·7
117	1396·8	1403·5	1410·1	1416·8	1423·4	1430·0	1436·6	1443·2	1449·8	1456·4	6·6
118	4 1462·9	1469·5	1476·0	1482·6	1489·1	1495·6	1502·1	1508·6	1515·1	1521·5	6·5
119	1528·0	1534·4	1540·9	1547·3	1553·7	1560·1	1566·5	1572·9	1579·2	1585·6	6·4
120	1591·9	1598·3	1604·6	1610·9	1617·2	1623·5	1629·8	1636·1	1642·3	1648·6	6·3
121	4 1654·8	1661·1	1667·3	1673·5	1679·7	1685·9	1692·1	1698·2	1704·4	1710·5	6·2
122	1716·7	1722·8	1728·9	1735·0	1741·1	1747·2	1753·3	1759·4	1765·4	1771·5	6·1
123	1777·5	1783·6	1789·6	1795·6	1801·6	1807·6	1813·6	1819·6	1825·6	1831·5	6·0

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TABLE II.—*continued.*

A General Table of Values of $\frac{d^2}{w} S$ for Ogival-headed shot. $\left(\frac{d^2}{w} S = S_V - S_v\right)$.

v.	0	1	2	3	4	5	6	7	8	9	Diff.
f.s.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	+
124	4 1837·5	1843·4	1849·4	1855·3	1861·2	1867·1	1873·0	1878·9	1884·8	1890·6	5·9
125	1896·5	1902·3	1908·2	1914·0	1919·8	1925·6	1931·5	1937·3	1943·0	1948·8	5·8
126	1954·6	1960·4	1966·1	1971·9	1977·6	1983·3	1989·0	1994·8	2000·5	2006·2	5·7
127	4 2011·8	2017·5	2023·2	2028·9	2034·5	2040·2	2045·8	2051·4	2057·0	2062·7	5·6
128	2068·3	2073·9	2079·5	2085·0	2090·6	2096·2	2101·8	2107·3	2112·9	2118·4	5·6
129	2123·9	2129·4	2135·0	2140·5	2146·0	2151·5	2157·0	2162·4	2167·9	2173·4	5·5
130	4 2178·8	2184·3	2189·7	2195·1	2200·6	2206·0	2211·4	2216·8	2222·2	2227·6	5·4
131	2233·0	2238·4	2243·7	2249·1	2254·5	2259·8	2265·1	2270·5	2275·8	2281·1	5·3
132	2286·4	2291·8	2297·1	2302·4	2307·6	2312·9	2318·2	2323·5	2328·7	2334·0	5·3
133	4 2339·2	2344·5	2349·7	2355·0	2360·2	2365·4	2370·6	2375·8	2381·0	2386·2	5·2
134	2391·4	2396·6	2401·8	2406·9	2412·1	2417·3	2422·4	2427·6	2432·7	2437·8	5·2
135	2443·0	2448·1	2453·2	2458·3	2463·4	2468·5	2473·6	2478·7	2483·8	2488·9	5·1
136	4 2493·9	2499·0	2504·1	2509·1	2514·2	2519·2	2524·3	2529·3	2534·3	2539·4	5·0
137	2544·4	2549·4	2554·4	2559·4	2564·4	2569·4	2574·4	2579·4	2584·3	2589·3	5·0
138	2594·3	2599·2	2604·2	2609·1	2614·1	2619·0	2624·0	2628·9	2633·8	2638·8	4·9
139	4 2643·7	2648·6	2653·5	2658·4	2663·3	2668·2	2673·1	2678·0	2682·9	2687·8	4·9
140	2692·6	2697·5	2702·4	2707·2	2712·1	2717·0	2721·8	2726·7	2731·5	2736·3	4·9
141	2741·2	2746·0	2750·8	2755·7	2760·5	2765·3	2770·1	2774·9	2779·7	2784·5	4·8
142	4 2789·3	2794·1	2798·9	2803·7	2808·5	2813·2	2818·0	2822·8	2827·5	2832·3	4·8
143	2837·1	2841·8	2846·6	2851·3	2856·0	2860·8	2865·5	2870·2	2875·0	2879·7	4·7
144	2884·4	2889·1	2893·8	2898·6	2903·3	2908·0	2912·7	2917·4	2922·1	2926·7	4·7
145	4 2931·4	2936·1	2940·8	2945·5	2950·1	2954·8	2959·5	2964·1	2968·8	2973·5	4·7
146	2978·1	2982·8	2987·4	2992·1	2996·7	3001·3	3006·0	3010·6	3015·2	3019·9	4·6
147	3024·5	3029·1	3033·7	3038·4	3043·0	3047·6	3052·2	3056·8	3061·4	3066·0	4·6
148	4 3070·6	3075·2	3079·8	3084·4	3089·0	3093·5	3098·1	3102·7	3107·3	3111·8	4·6
149	3116·4	3121·0	3125·6	3130·1	3134·7	3139·2	3143·8	3148·3	3152·9	3157·4	4·6
150	3162·0	3166·5	3171·0	3175·6	3180·1	3184·6	3189·2	3193·7	3198·2	3202·7	4·5
151	4 3207·2	3211·8	3216·3	3220·8	3225·3	3229·8	3234·3	3238·8	3243·3	3247·8	4·5
152	3252·3	3256·8	3261·3	3265·8	3270·3	3274·8	3279·3	3283·8	3288·3	3292·8	4·5
153	3297·2	3301·7	3306·2	3310·6	3315·1	3319·6	3324·1	3328·5	3333·0	3337·5	4·5
154	4 3342·0	3346·4	3350·9	3355·3	3359·8	3364·3	3368·7	3373·2	3377·6	3382·1	4·5
155	3386·5	3391·0	3395·4	3399·9	3404·3	3408·7	3413·2	3417·6	3422·0	3426·5	4·4
156	3430·9	3435·3	3439·8	3444·2	3448·6	3453·0	3457·4	3461·9	3466·3	3470·7	4·4
157	4 3475·1	3479·5	3483·9	3488·3	3492·7	3497·1	3501·5	3505·9	3510·3	3514·7	4·4
158	3519·1	3523·5	3527·9	3532·3	3536·7	3541·1	3545·4	3549·8	3554·2	3558·6	4·4
159	3563·0	3567·3	3571·7	3576·1	3580·4	3584·8	3589·1	3593·5	3597·9	3602·2	4·4
160	4 3606·6	3610·9	3615·3	3619·6	3624·0	3628·3	3632·6	3637·0	3641·3	3645·7	4·3
161	3650·0	3654·3	3658·7	3663·0	3667·3	3671·6	3676·0	3680·3	3684·6	3688·9	4·3
162	3693·3	3697·6	3701·9	3706·1	3710·5	3714·8	3719·1	3723·4	3727·7	3732·0	4·3
163	4 3736·3	3740·6	3744·9	3749·2	3753·5	3757·8	3762·1	3766·4	3770·6	3774·9	4·3
164	3779·2	3783·5	3787·8	3792·0	3796·3	3800·6	3804·9	3809·1	3813·4	3817·6	4·3
165	3821·9	3826·2	3830·4	3834·7	3838·9	3843·2	3847·4	3851·7	3855·9	3860·2	4·3
166	4 3864·4	3868·7	3872·9	3877·2	3881·4	3885·6	3889·9	3894·1	3898·3	3902·5	4·2
167	3906·8	3911·0	3915·2	3919·5	3923·7	3927·9	3932·1	3936·3	3940·5	3944·7	4·2
168	3949·0	3953·2	3957·4	3961·6	3965·8	3970·0	3974·2	3978·4	3982·6	3986·7	4·2
169	4 3990·9	3995·1	3999·3	4003·5	4007·7	4011·9	4016·0	4020·2	4024·4	4028·6	4·2
170	4032·7	4036·9	4041·1	4045·2	4049·4	4053·6	4057·7	4061·9	4066·0	4070·2	4·2
171	4074·3	4078·5	4082·6	4086·8	4090·9	4095·1	4099·2	4103·3	4107·5	4111·6	4·1
172	4 4115·7	4119·9	4124·0	4128·1	4132·3	4136·4	4140·5	4144·6	4148·7	4152·9	4·1
173	4157·0	4161·1	4165·2	4169·3	4173·4	4177·5	4181·6	4185·7	4189·8	4193·9	4·1
174	4198·0	4202·1	4206·2	4210·3	4214·4	4218·5	4222·6	4226·7	4230·8	4234·8	4·1
175	4 4238·9	4243·0	4247·1	4251·2	4255·3	4259·3	4263·4	4267·5	4271·5	4275·6	4·1
176	4279·6	4283·7	4287·8	4291·8	4295·9	4300·0	4304·0	4308·0	4312·1	4316·1	4·1
177	4320·2	4324·2	4328·3	4332·3	4336·4	4340·4	4344·4	4348·5	4352·5	4356·5	4·0
178	4 4360·5	4364·6	4368·6	4372·6	4376·6	4380·7	4384·7	4388·7	4392·7	4396·7	4·0
179	4400·7	4404·7	4408·8	4412·8	4416·8	4420·8	4424·8	4428·8	4432·8	4436·8	4·0
180	4440·8	4444·7	4448·7	4452·7	4456·7	4460·7	4464·7	4468·7	4472·6	4476·6	4·0

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TABLE II.—*continued.*

A General Table of Values of $\frac{d^2}{w}S$ for Ogival-headed shot. $\left(\frac{d^2}{w}S = S_V - S_v\right)$.

v.	0	1	2	3	4	5	6	7	8	9	Diff.
f.s.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	+
181	4 4480·6	4484·6	4488·5	4492·5	4496·5	4500·5	4504·4	4508·4	4512·4	4516·3	4·0
182	4520·3	4524·2	4528·2	4532·2	4536·1	4540·1	4544·0	4548·0	4551·9	4555·9	4·0
183	4559·8	4563·7	4567·7	4571·6	4575·6	4579·5	4583·4	4587·4	4591·3	4595·2	3·9
184	4 4599·2	4603·1	4607·0	4610·9	4614·9	4618·8	4622·7	4626·6	4630·5	4634·4	3·9
185	4638·4	4642·3	4646·2	4650·1	4654·0	4657·9	4661·8	4665·7	4669·6	4673·5	3·9
186	4677·4	4681·3	4685·2	4689·1	4693·0	4696·9	4700·8	4704·6	4708·5	4712·4	3·9
187	4 4716·3	4720·2	4724·1	4727·9	4731·8	4735·7	4739·6	4743·4	4747·3	4751·2	3·9
188	4755·0	4758·9	4762·8	4766·7	4770·5	4774·4	4778·2	4782·1	4786·0	4789·8	3·9
189	4793·7	4797·5	4801·4	4805·2	4809·1	4812·9	4816·8	4820·6	4824·5	4828·3	3·8
190	4 4832·2	4836·0	4839·8	4843·7	4847·5	4851·4	4855·2	4859·0	4862·8	4866·7	3·8
191	4870·5	4874·3	4878·1	4882·0	4885·8	4889·6	4893·4	4897·3	4901·1	4904·9	3·8
192	4908·7	4912·5	4916·3	4920·1	4923·9	4927·7	4931·5	4935·3	4939·1	4942·9	3·8
193	4 4946·7	4950·5	4954·3	4958·1	4961·9	4965·7	4969·4	4973·7	4977·0	4980·7	3·8
194	4984·5	4988·3	4992·1	4995·8	4999·6	5003·4	5007·1	5010·9	5014·7	5018·4	3·8
195	5022·2	5025·9	5029·7	5033·4	5037·2	5040·9	5044·7	5048·4	5052·1	5055·9	3·7
196	4 5059·6	5063·4	5067·1	5070·8	5074·6	5078·3	5082·0	5085·7	5089·4	5093·1	3·7
197	5096·9	5100·6	5104·3	5108·0	5111·7	5115·4	5119·1	5122·8	5126·5	5130·2	3·7
198	5133·9	5137·5	5141·2	5144·9	5148·6	5152·3	5156·0	5159·6	5163·3	5166·9	3·7
199	4 5170·6	5174·3	5177·9	5181·6	5185·2	5188·9	5192·5	5196·2	5199·8	5203·4	3·6
200	5207·1	5210·7	5214·3	5218·0	5221·6	5225·2	5228·8	5232·5	5236·1	5239·7	3·6
201	5243·3	5246·9	5250·5	5254·1	5257·7	5261·3	5264·9	5268·5	5272·1	5275·7	3·6
202	4 5279·2	5282·8	5286·4	5290·0	5293·6	5297·2	6300·7	5304·3	5307·8	5311·4	3·6
203	5314·9	5318·5	5322·0	5325·6	5329·1	5332·7	5336·2	5339·7	5343·3	5346·8	3·5
204	5350·3	5353·8	5357·3	5360·9	5364·4	5367·9	5371·4	5374·9	5378·4	5381·9	3·5
205	4 5385·4	5388·9	5392·4	5395·9	5399·4	5402·9	5406·3	5409·8	5413·3	5416·7	3·5
206	5420·2	5423·7	5427·1	5430·6	5434·1	5437·5	5441·0	5444·4	5447·8	5451·3	3·5
207	5454·7	5458·1	5461·6	5465·0	5468·4	5471·9	5475·3	5478·7	5482·1	5485·5	3·4
208	4 5488·9	5492·3	5495·7	5499·1	5502·5	5505·9	5509·3	5512·7	5516·1	5519·4	3·4
209	5522·8	5526·2	5529·6	5532·9	5536·3	5539·7	5543·0	5546·4	5549·7	5553·1	3·4
210	5556·4	5559·8	5563·1	5566·4	5569·8	5573·1	5576·5	5579·8	5583·1	5586·4	3·3
211	4 5589·7	5593·0	5596·4	5599·7	5603·0	5606·3	5609·6	5612·9	5616·2	5619·5	3·3
212	5622·8	5626·1	5629·3	5632·6	5635·9	5639·2	5642·5	5645·7	5649·0	5652·3	3·3
213	5655·5	5658·8	5662·0	5665·3	5668·6	5671·8	5675·1	5678·3	5681·5	5684·8	3·2
214	4 5688·0	5691·2	5694·5	5697·7	5700·9	5704·2	5707·4	5710·6	5713·8	5717·0	3·2
215	5720·2	5723·4	5726·6	5729·9	5733·1	5736·3	5739·5	5742·6	5745·8	5749·0	3·2
216	5752·2	5755·4	5758·6	5761·8	5764·9	5768·1	5771·3	5774·4	5777·6	5780·8	3·2
217	4 5783·9	5787·1	5790·2	5793·4	5796·6	5799·7	5802·9	5806·0	5809·1	5812·2	3·1
218	5815·4	5818·5	5821·6	5824·8	5827·9	5831·0	5834·1	5837·3	5840·4	5843·5	3·1
219	5846·6	5849·7	5852·8	5855·9	5859·0	5862·1	5865·2	5868·3	5871·4	5874·4	3·1
220	4 5877·5	5880·6	5883·7	5886·8	5889·9	5893·0	5896·0	5899·1	5902·1	5905·2	3·1
221	5908·3	5911·3	5914·4	5917·4	5920·5	5923·6	5926·6	5929·6	5932·7	5935·7	3·0
222	5938·7	5941·8	5944·8	5947·8	5950·9	5953·9	5956·9	5959·9	5963·0	5966·0	3·0
223	4 5969·0	5972·0	5975·0	5978·0	5981·0	5984·0	5987·0	5990·0	5993·0	5996·0	3·0
224	5999·0	6002·0	6004·9	6007·9	6010·9	6013·9	6016·9	6019·8	6022·8	6025·8	3·0
225	6028·7	6031·7	6034·6	6037·6	6040·5	6043·5	6046·5	6049·4	6052·4	6055·3	3·0
226	4 6058·3	6061·2	6064·1	6067·1	6070·0	6072·9	6075·9	6078·8	6081·7	6084·7	2·9
227	6087·6	6090·5	6093·4	6096·3	6099·3	6102·2	6105·1	6108·0	6110·9	6113·8	2·9
228	6116·7	6119·6	6122·5	6125·4	6128·3	6131·2	6134·1	6137·0	6139·9	6142·8	2·9
229	4 6145·7	6148·6	6151·5	6154·4	6157·3	6160·2	6163·1	6166·0	6168·8	6171·7	2·9
230	6174·6	6177·5	6180·4	6183·3	6186·2	6189·1	6191·9	6194·8	6197·7	6200·6	2·9
231	6203·5	6206·4	6209·3	6212·1	6215·0	6217·9	6220·8	6223·7	6226·6	6229·5	2·9
232	4 6232·3	6235·2	6238·1	6241·0	6243·9	6246·8	6249·7	6252·6	6255·4	6258·3	2·9
233	6261·2	6264·1	6267·0	6269·9	6272·8	6275·7	6278·6	6281·5	6284·3	6287·2	2·9
234	6290·1	6293·0	6295·9	6298·8	6301·7	6304·6	6307·5	6310·4	6313·3	6316·2	2·9
235	4 6319·0	6322·0	6324·9	6327·7	6330·6	6333·5	6336·4	6339·3	6342·2	6345·1	2·9
236	6348·0	6350·9	6353·8	6356·7	6359·6	6362·5	6365·4	6368·3	6371·2	6374·1	2·9
237	6377·0	6379·9	6382·8	6385·7	6388·6	6391·5	6394·4	6397·3	6400·2	6403·1	2·9

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TABLE II.—*continued.*

A General Table of Values of $\frac{d^2}{w} S$ for Ogival-headed shot. $\left(\frac{d^2}{w} S = S_V - S_v\right)$.

v.	0	1	2	3	4	5	6	7	8	9	Diff.
f.s.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	+
238	4 6406·0	6408·9	6411·8	6414·8	6417·7	6420·6	6423·5	6426·4	6429·3	6432·2	2·9
239	6435·1	6438·0	6440·9	6443·8	6446·8	6449·7	6452·6	6455·5	6458·4	6461·3	2·9
240	6464·2	6467·1	6470·1	6473·0	6475·9	6478·8	6481·7	6484·6	6487·6	6490·5	2·9
241	4 6493·4	6496·3	6499·2	6502·2	6505·1	6508·0	6510·9	6513·8	6516·8	6519·7	2·9
242	6522·6	6525·6	6528·5	6531·4	6534·3	6537·3	6540·2	6543·1	6546·1	6549·0	2·9
243	6551·9	6554·9	6557·8	6560·7	6563·7	6566·6	6569·5	6572·5	6575·4	6578·3	2·9
244	4 6581·3	6584·2	6587·2	6590·1	6593·0	6596·0	6598·9	6601·8	6604·8	6607·7	2·9
245	6610·6	6613·6	6616·5	6619·5	6622·4	6625·3	6628·3	6631·2	6634·2	6637·1	2·9
246	6640·1	6643·0	6645·9	6648·9	6651·8	6654·8	6657·7	6660·6	6663·6	6666·5	2·9
247	4 6669·5	6672·4	6675·4	6678·3	6681·3	6684·2	6687·2	6690·1	6693·0	6696·0	2·9
248	6698·9	6701·9	6704·8	6707·8	6710·7	6713·7	6716·6	6719·6	6722·5	6725·5	2·9
249	6728·4	6731·3	6734·3	6737·2	6740·2	6743·1	6746·1	6749·0	6752·0	6754·9	2·9
250	4 6757·8	6760·7	6763·7	6766·7	6769·6	6772·6	6775·5	6778·4	6781·4	6784·3	2·9
251	6787·3	6790·2	6793·1	6796·1	6799·0	6802·0	6804·9	6807·8	6810·8	6813·7	2·9
252	6816·6	6819·6	6822·5	6825·4	6828·4	6831·3	6834·2	6837·1	6840·1	6843·0	2·9
253	4 6845·9	6848·8	6851·8	6854·7	6857·6	6860·5	6863·5	6866·4	6869·3	6872·2	2·9
254	6875·1	6878·1	6881·0	6883·9	6886·8	6889·7	6892·6	6895·6	6898·5	6901·4	2·9
255	6904·3	6907·2	6910·1	6913·0	6915·9	6918·8	6921·7	6924·6	6927·5	6930·4	2·9
256	4 6933·3	6936·2	6939·1	6942·0	6944·9	6947·8	6950·6	6953·5	6956·4	6959·3	2·9
257	6962·2	6965·0	6967·9	6970·8	6973·7	6976·5	6979·4	6982·3	6985·1	6988·0	2·9
258	6990·9	6993·7	6996·6	6999·4	7002·3	7005·1	7008·0	7010·8	7013·7	7016·5	2·9
259	4 7019·4	7022·2	7025·0	7027·9	7030·7	7033·5	7036·4	7039·2	7042·0	7044·8	2·8
260	7047·7	7050·5	7053·3	7056·1	7058·9	7061·7	7064·5	7067·4	7070·2	7073·0	2·8
261	7075·8	7078·6	7081·4	7084·2	7087·0	7089·7	7092·5	7095·3	7098·1	7100·9	2·8
262	4 7103·7	7106·5	7109·2	7112·0	7114·8	7117·6	7120·3	7123·1	7125·9	7128·6	2·8
263	7131·4	7134·2	7136·9	7139·7	7142·4	7145·2	7147·9	7150·7	7153·4	7156·2	2·8
264	7158·9	7161·7	7164·4	7167·1	7169·9	7172·6	7175·4	7178·1	7180·8	7183·5	2·7
265	4 7186·3	7189·0	7191·7	7194·4	7197·1	7199·9	7202·6	7205·3	7208·0	7210·7	2·7
266	7213·4	7216·1	7218·8	7221·5	7224·2	7226·9	7229·6	7232·3	7235·0	7237·7	2·7
267	7240·4	7243·1	7245·8	7248·5	7251·2	7253·8	7256·5	7259·2	7261·9	7264·5	2·7
268	4 7267·2	7269·9	7272·5	7275·2	7277·9	7280·5	7283·2	7285·9	7288·5	7291·2	2·7
269	7293·8	7296·5	7299·1	7301·8	7304·4	7307·1	7309·7	7312·3	7315·0	7317·6	2·6
270	7320·2	7322·9	7325·5	7328·1	7330·8	7333·4	7336·0	7338·6	7341·2	7343·9	2·6
271	4 7346·5	7349·1	7351·7	7354·3	7356·9	7359·5	7362·1	7364·7	7367·3	7369·9	2·6
272	7372·5	7375·1	7377·7	7380·3	7382·9	7385·5	7388·1	7390·7	7393·3	7395·8	2·6
273	7398·4	7401·0	7403·6	7406·2	7408·7	7411·3	7413·9	7416·4	7419·0	7421·6	2·6
274	4 7424·1	7426·7	7429·3	7431·8	7434·4	7436·9	7439·5	7442·0	7444·6	7447·1	2·6
275	7449·7	7452·2	7454·8	7457·3	7459·8	7462·4	7464·9	7467·4	7470·0	7472·5	2·5
276	7475·0	7477·5	7480·1	7482·6	7485·1	7487·6	7490·1	7492·7	7495·2	7497·7	2·5
277	4 7500·2	7502·7	7505·2	7507·7	7510·2	7512·7	7515·2	7517·7	7520·2	7522·7	2·5
278	7525·2	7527·7	7530·1	7532·6	7535·1	7537·6	7540·1	7542·6	7545·0	7547·5	2·5
279	7550·0	7552·4	7554·9	7557·4	7559·9	7562·3	7564·8	7567·2	7569·7	7572·2	2·5
280	4 7574·6	7577·1	7579·5	7582·0	7584·4	9586·8	7589·3	7591·7	7594·2	7596·6	2·4
281	7599·0	7601·5	7603·9	7606·4	7608·8	7611·2	7613·6	7616·1	7618·5	7620·9	2·4
282	7623·3	7625·7	7628·2	7630·6	7633·0	7635·4	7637·8	7640·2	7642·6	7645·0	2·4
283	4 7647·4	7649·8	7652·2	7654·6	7657·0	7659·4	7661·8	7664·2	7666·6	7669·0	2·4
284	7671·3	7673·7	7676·1	7678·5	7680·9	7683·3	7685·6	7688·0	7690·4	7692·7	2·4
285	7695·1	7697·5	7699·8	7702·2	7704·6	7706·9	7709·3	7711·6	7714·0	7716·4	2.4
286	4 7718·7	7721·1	7723·4	7725·8	7728·1	7730·4	7732·8	7735·1	7737·5	7739·8	2·3
287	7742·1	7744·5	7746·8	7749·1	7751·5	7753·8	7756·1	7758·4	7760·8	7763·1	2·3
288	7765·4	7767·7	7770·0	7772·4	7774·7	7777·0	7779·3	7781·6	7783·9	7786·2	2·3
289	4 7788·5	7790·8	7793·1	7795·4	7797·7	7800·0	7802·3	7804·6	7806·9	7809·2	2·3
290	7811·5										

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TABLE III.

Inclination and Velocity Table. $\frac{d^2}{w} D = D_v - D_v$.*

v.	0	1	2	3	4	5	6	7	8	9
f.s.	degs.	degs.	degs.	degs.	degs.	degs.	degs.	degs.	degs.	degs.
40	0	·4838	·9640	1·4407	1·9137	2·3830	2·8488	3·3110	3·7689	4·2240
41	4·6757	5·1240	5·5688	6·0101	6·4482	6·8828	7·3141	7·7421	8·1660	8·5874
42	9·0056	9·4207	9·8327	10·2410	10·6467	11·0496	11·4494	11·8462	12·2397	12·6306
43	13·0187	13·4039	13·7862	14·1652	14·5419	14·9159	15·2872	15·6557	16·0211	16·3843
44	16·7450	17·1030	17·4585	17·8110	18·1614	18·5094	18·8549	19·1980	19·5383	19·8766
45	20·2125	20·5460	20·8772	21·2054	21·5320	21·8565	22·1788	22·4989	22·8169	23·1327
46	23·4463	23·7578	24·0671	24·3736	24·6788	24·9821	25·2834	25·5827	25·8801	26·1756
47	26·4691	26·7607	27·0503	27·3376	27·6234	27·9075	28·1897	28·4702	28·7486	29·0254
48	29·3006	29·5739	29·8455	30·1151	30·3833	30·6498	30·9147	31·1779	31·4393	31·6993
49	31·9576	32·2143	32·4695	32·7227	32·9747	33·2253	33·4743	33·7219	33·9679	34·2125
50	34·4557	34·6973	34·9375	35·1761	35·4134	35·6493	35·8837	36·1167	36·3480	36·5783
51	36·8073	37·0349	37·2613	37·4862	37·7099	37·9323	38·1534	38·3731	38·5914	38·8086
52	39·0246	39·2394	39·4529	39·6651	39·8762	40·0860	40·2947	40·5022	40·7083	40·9135
53	41·1175	41·3204	41·5221	41·7225	41·9221	42·1205	42·3179	42·5142	42·7095	42·9037
54	43·0967	43·2887	43·4795	43·6690	43·8578	44·0456	44·2324	44·4182	44·6031	44·7870
55	44·9698	45·1516	45·3325	45·5122	45·6910	45·8689	46·0457	46·2217	46·3964	46·5705
56	46·7437	46·9160	47·0874	47·2581	47·4277	47·5965	47·7644	47·9314	48·0973	48·2625
57	48·4270	48·5906	48·7534	48·9153	49·0764	49·2368	49·3963	49·5551	49·7130	49·8701
58	50·0265	50·1822	50·3370	50·4909	50·6442	50·7968	50·9487	51·0999	51·2505	51·4002
59	51·5492	51·6975	51·8451	51·9917	52·1378	52·2832	52·4280	52·5721	52·7155	52·8583
60	53·0003	53·1417	53·2825	53·4224	53·5618	53·7005	53·8386	53·9761	54·1130	54·2492
61	54·3847	54·5196	54·6539	54·7875	54·9205	55·0529	55·1846	55·3158	55·4462	55·5761
62	55·7054	55·8342	55·9623	56·0899	56·2169	56·3433	56·4690	56·5942	56·7188	56·8428
63	56·9663	57·0891	57·2114	57·3330	57·4542	57·5749	57·6950	57·8146	57·9338	58·0523
64	58·1703	58·2878	58·4046	58·5209	58·6367	58·7521	58·8669	58·9832	59·0949	59·2081
65	59·3209	59·4332	59·5449	59·6562	59·7669	59·8772	59·9869	60·0961	60·2047	60·3130
66	60·4207	60·5280	60·6348	60·7411	60·8470	60·9523	61·0572	61·1616	61·2654	61·3688
67	61·4719	61·5744	61·6766	61·7783	61·8796	61·9804	62·0808	62·1807	62·2802	62·3793
68	62·4779	62·5761	62·6739	62·7711	62·8680	62·9646	63·0607	63·1565	63·2519	63·3468
69	63·4414	63·5356	63·6294	63·7227	63·8157	63·9084	64·0006	64·0924	64·1838	64·2749
70	64·3656	64·4559	64·5459	64·6356	64·7249	64·8137	64·9022	64·9903	65·0779	65·1652
71	65·2522	65·3388	65·4250	65·5107	65·5962	65·6813	65·7660	65·8504	65·9345	66·0182
72	66·1015	66·1845	66·2671	66·3494	66·4313	66·5128	66·5940	66·6749	66·7553	66·8355
73	66·9153	66·9949	67·0740	67·1529	67·2314	67·3096	67·3875	67·4649	67·5422	67·6190
74	67·6955	67·7717	67·8476	67·9231	67·9983	68·0733	68·1479	68·2223	68·2964	68·3702
75	68·4436	68·5168	68·5896	68·6620	68·7342	68·8062	68·8778	68·9492	69·0204	69·0912
76	69·1617	69·2318	69·3017	69·3712	69·4404	69·5094	69·5780	69·6464	69·7145	69·7823
77	69·8497	69·9169	69·9838	70·0503	70·1166	70·1826	70·2483	70·3137	70·3787	70·4436
78	70·5082	70·5725	70·6365	70·7004	70·7639	70·8271	70·8901	70·9527	71·0149	71·0770
79	71·1388	71·2004	71·2617	71·3228	71·3837	71·4442	71·5045	71·5646	71·6244	71·6839
80	71·7432	71·8023	71·8611	71·9196	71·9779	72·0359	72·0937	72·1513	72·2086	72·2656
81	72·3225	72·3791	72·4354	72·4915	72·5473	72·6030	72·6584	72·7135	72·7685	72·8232
82	72·8776	72·9317	72·9856	73·0393	73·0927	73·1458	73·1988	73·2514	73·3038	73·3560
83	73·4079	73·4596	73·5111	73·5622	73·6132	73·6639	73·7145	73·7648	73·8149	73·8647
84	73·9143	73·9636	74·0127	74·0615	74·1101	74·1585	74·2067	74·2546	74·3023	74·3498
85	74·3971	74·4441	74·4910	74·5376	74·5839	74·6301	74·6760	74·7217	74·7670	74·8123
86	74·8573	74·9022	74·9468	74·9912	75·0355	75·0795	75·1233	75·1669	75·2104	75·2536
87	75·2966	75·3395	75·3821	75·4246	75·4668	75·5089	75·5507	75·5924	75·6339	75·6752
88	75·7163	75·7572	75·7980	75·8385	75·8788	75·9190	75·9590	75·9988	76·0384	76·0778
89	76·1171	76·1562	76·1952	76·2339	76·2725	76·3109	76·3492	76·3873	76·4252	76·4629
90	76·5005	76·5379	76·5751	76·6121	76·6490	76·6857	76·7223	76·7588	76·7951	76·8312

* Calculated from the formula of W. D. Niven, Esq., M.A.

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TABLE III.—*continued.*

Inclination and Velocity Table. $\frac{d^2}{w} D = D_V - D_v$.

v.	0	1	2	3	4	5	6	7	8	9
f.s.	degs.	degs.	degs.	degs.	degs.	degs.	degs.	degs.	degs.	degs.
91	76·8871	76·9029	76·9385	76·9739	77·0092	77·0444	77·0794	77·1142	77·1489	77·1835
92	77·2179	77·2522	77·2863	77·3203	77·3541	77·3878	77·4213	77·4547	77·4879	77·5210
93	77·5540	77·5868	77·6195	77·6520	77·6844	77·7167	77·7488	77·7807	77·8125	77·8442
94	77·8757	77·9071	77·9384	77·9695	78·0005	78·0314	78·0622	78·0929	78·1234	78·1538
95	78·1841	78·2142	78·2442	78·2741	78·3039	78·3335	78·3630	78·3924	78·4216	78·4508
96	78·4798	78·5087	78·5375	78·5662	78·5947	78·6231	78·6514	78·6796	78·7076	78·7356
97	78·7634	78·7911	78·8188	78·8463	78·8736	78·9009	78·9280	78·9551	78·9819	79·0087
98	79·0354	79·0621	79·0886	79·1150	79·1413	79·1675	79·1936	79·2195	79·2454	79·2712
99	79·2968	79·3224	79·3478	79·3731	79·3983	79·4234	79·4484	79·4734	79·4982	79·5230
100	79·5476	79·5722	79·5966	79·6210	79·6453	79·6695	79·6935	79·7175	79·7414	79·7652
101	79·7889	79·8124	79·8359	79·8593	79·8826	79·9058	79·9289	79·9519	79·9748	79·9976
102	80·0203	80·0430	80·0655	80·0879	80·1102	80·1324	80·1544	80·1763	80·1981	80·2197
103	80·2412	80·2625	80·2837	80·3048	80·3256	80·3462	80·3667	80·3869	80·4071	80·4270
104	80·4466	80·4661	80·4854	80·5045	80·5234	80·5420	80·5605	80·5787	80·5967	80·6145
105	80·6321	80·6495	80·6667	80·6835	80·7003	80·7169	80·7333	80·7495	80·7654	80·7813
106	80·7970	80·8126	80·8280	80·8432	80·8583	80·8733	80·8882	80·9029	80·9175	80·9319
107	80·9463	80·9606	80·9747	80·9886	81·0026	81·0164	81·0301	81·0437	81·0573	81·0707
108	81·0841	81·0973	81·1105	81·1236	81·1366	81·1495	81·1624	81·1751	81·1877	81·2003
109	81·2129	81·2253	81·2377	81·2501	81·2623	81·2745	81·2866	81·2986	81·3105	81·3224
110	81·3342	81·3460	81·3578	81·3695	81·3811	81·3927	81·4042	81·4156	81·4269	81·4382
111	81·4495	81·4607	81·4719	81·4829	81·4939	81·5049	81·5159	81·5268	81·5377	81·5485
112	81·5593	81·5700	81·5807	81·5913	81·6019	81·6124	81·6230	81·6334	81·6439	81·6543
113	81·6647	81·6750	81·6853	81·6955	81·7057	81·7159	81·7260	81·7361	81·7462	81·7562
114	81·7662	81·7761	81·7861	81·7960	81·8058	81·8156	81·8254	81·8351	81·8448	81·8545
115	81·8641	81·8737	81·8833	81·8929	81·9024	81·9119	81·9213	81·9307	81·9401	81·9495
116	81·9588	81·9681	81·9774	81·9866	81·9958	82·0049	82·0141	82·0232	82·0322	82·0413
117	82·0503	82·0592	82·0682	82·0771	82·0860	82·0948	82·1036	82·1124	82·1212	82·1299
118	82·1386	82·1473	82·1559	82·1645	82·1731	82·1817	82·1902	82·1988	82·2073	82·2157
119	82·2241	82·2325	82·2408	82·2492	82·2575	82·2657	82·2740	82·2822	82·2903	82·2985
120	82·3066	82·3147	82·3228	82·3309	82·3389	82·3469	82·3549	82·3629	82·3708	82·3787
121	82·3865	82·3944	82·4022	82·4100	82·4178	82·4255	82·4333	82·4410	82·4486	82·4563
122	82·4639	82·4715	82·4790	82·4865	82·4940	82·5015	82·5090	82·5164	82·5238	82·5312
123	82·5386	82·5459	82·5533	82·5606	82·5679	82·5751	82·5824	82·5896	82·5968	82·6040
124	82·6112	82·6183	82·6254	82·6324	82·6395	82·6465	82·6535	82·6605	82·6675	82·6744
125	82·6814	82·6883	82·6951	82·7019	82·7088	82·7156	82·7224	82·7291	82·7359	82·7427
126	82·7494	82·7561	82·7627	82·7694	82·7760	82·7826	82·7892	82·7957	82·8023	82·8088
127	82·8153	82·8218	82·8283	82·8348	82·8412	82·8477	82·8541	82·8604	82·8668	82·8731
128	82·8794	82·8857	82·8920	82·8983	82·9045	82·9107	82·9169	82·9231	82·9292	82·9354
129	82·9415	82·9477	82·9538	82·9599	82·9660	82·9720	82·9780	82·9840	82·9900	82·9960
130	83·0019	83·0077	83·0138	83·0197	83·0256	83·0315	83·0373	83·0432	83·0490	83·0548
131	83·0606	83·0664	83·0721	83·0779	83·0836	83·0893	83·0950	83·1007	83·1063	83·1119
132	83·1176	83·1232	83·1288	83·1344	83·1400	83·1455	83·1511	83·1566	83·1621	83·1676
133	83·1730	83·1785	83·1840	83·1894	83·1949	83·2003	83·2057	83·2110	83·2164	83·2217
134	83·2271	83·2324	83·2377	83·2430	83·2483	83·2536	83·2588	83·2641	83·2693	83·2745
135	83·2797	83·2849	83·2900	83·2951	83·3003	83·3054	83·3105	83·3156	83·3207	83·3257
136	83·3308	83·3359	83·3409	83·3459	83·3509	83·3560	83·3609	83·3659	83·3709	83·3759
137	83·3808	83·3857	83·3906	83·3955	83·4004	83·4053	83·4101	83·4150	83·4198	83·4247
138	83·4295	83·4343	83·4391	83·4438	83·4486	83·4533	83·4581	83·4628	83·4676	83·4723
139	83·4770	83·4817	83·4863	83·4910	83·4956	83·5003	83·5049	83·5095	83·5141	83·5187
140	83·5233	83·5279	83·5325	83·5371	83·5417	83·5462	83·5507	83·5553	83·5598	83·5642
141	83·5687	83·5732	83·5777	83·5821	83·5866	83·5910	83·5954	83·5999	83·6043	83·6087
142	83·6130	83·6174	83·6218	83·6261	83·6305	83·6348	83·6392	83·6435	83·6478	83·6522
143	83·6565	83·6607	83·6650	83·6693	83·6735	83·6778	83·6820	83·6862	83·6904	83·6946
144	83·6988	83·7030	83·7072	83·7114	83·7156	83·7197	83·7239	83·7280	83·7321	83·7362

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TABLE III.—*continued.*

Inclination and Velocity Table. $\frac{d^2}{w} D = D_V - D_v$.

v.	0	1	2	3	4	5	6	7	8	9
f.s.	degs.	degs.	degs.	degs.	degs.	degs.	degs.	degs.	degs.	degs.
145	83·7403	83·7444	83·7485	83·7526	83·7567	83·7608	83·7649	83·7689	83·7730	83·7770
146	83·7810	83·7850	83·7891	83·7930	83·7970	83·8010	83·8050	83·8090	83·8130	83·8170
147	83·8209	83·8249	83·8288	83·8327	83·8366	83·8406	83·8445	83·8484	83·8522	83·8561
148	83·8600	83·8639	83·8677	83·8715	83·8754	83·8792	83·8830	83·8869	83·8907	83·8945
149	83·8983	83·9021	83·9059	83·9096	83·9134	83·9172	83·9209	83·9247	83·9285	83·9322
150	83·9359	83·9396	83·9433	83·9470	83·9507	83·9544	83·9581	83·9617	83·9654	83·9691
151	83·9727	83·9764	83·9800	83·9837	83·9873	83·9909	83·9946	83·9982	84·0018	84·0054
152	84·0090	84·0126	84·0161	84·0197	84·0233	84·0269	84·0304	84·0340	84·0375	84·0410
153	84·0446	84·0481	84·0516	84·0551	84·0587	84·0622	84·0657	84·0692	84·0727	84·0762
154	84·0796	84·0831	84·0866	84·0900	84·0935	84·0969	84·1004	84·1038	84·1072	84·1106
155	84·1140	84·1174	84·1208	84·1242	84·1276	84·1310	84·1344	84·1378	84·1412	84·1445
156	84·1479	84·1513	84·1546	84·1579	84·1613	84·1646	84·1679	84·1713	84·1746	84·1779
157	84·1812	84·1845	84·1878	84·1911	84·1943	84·1976	84·2009	84·2041	84·2074	84·2107
158	84·2139	84·2172	84·2204	84·2237	84·2269	84·2301	84·2333	84·2366	84·2398	84·2430
159	84·2461	84·2493	84·2525	84·2557	84·2588	84·2620	84·2652	84·2683	84·2715	84·2746
160	84·2778	84·2809	84·2840	84·2871	84·2902	84·2933	84·2965	84·2996	84·3027	84·3058
161	84·3088	84·3119	84·3150	84·3180	84·3210	84·3242	84·3272	84·3302	84·3333	84·3363
162	84·3394	84·3424	84·3454	84·3484	84·3514	84·3544	84·3574	84·3604	84·3634	84·3664
163	84·3694	84·3724	84·3753	84·3783	84·3813	84·3843	84·3872	84·3902	84·3931	84·3960
164	84·3990	84·4019	84·4048	84·4078	84·4107	84·4136	84·4165	84·4194	84·4223	84·4252
165	84·4281	84·4310	84·4339	84·4367	84·4396	84·4425	84·4453	84·4482	84·4510	84·4539
166	84·4567	84·4595	84·4624	84·4652	84·4680	84·4709	84·4737	84·4765	84·4793	84·4821
167	84·4849	84·4877	84·4905	84·4933	84·4961	84·4988	84·5016	84·5044	84·5070	84·5099
168	84·5127	84·5154	84·5181	84·5209	84·5236	84·5263	84·5291	84·5318	84·5345	84·5372
169	84·5399	84·5426	84·5453	84·5480	84·5508	84·5534	84·5561	84·5588	84·5615	84·5641
170	84·5668	84·5695	84·5721	84·5748	84·5775	84·5801	84·5828	84·5854	84·5880	84·5907
171	84·5933	84·5959	84·5985	84·6012	84·6038	84·6064	84·6090	84·6116	84·6142	84·6168
172	84·6193	84·6219	84·6245	84·6271	84·6297	84·6322	84·6348	84·6373	84·6399	84·6424
173	84·6449	84·6475	84·6500	84·6525	84·6550	84·6575	84·6601	84·6626	84·6651	84·6676
174	84·6701	84·6726	84·6750	84·6776	84·6800	84·6825	84·6850	84·6875	84·6899	84·6924
175	84·6948	84·6973	84·6997	84·7022	84·7046	84·7071	84·7095	84·7119	84·7144	84·7168
176	84·7192	84·7216	84·7240	84·7264	84·7288	84·7312	84·7336	84·7360	84·7384	84·7408
177	84·7432	84·7455	84·7479	84·7503	84·7526	84·7550	84·7574	84·7597	84·7621	84·7645
178	84·7668	84·7692	84·7715	84·7739	84·7762	84·7785	84·7809	84·7832	84·7855	84·7878
179	84·7902	84·7925	84·7948	84·7972	84·7994	84·8017	84·8040	84·8063	84·8086	84·8109
180	84·8131	84·8154	84·8177	84·8199	84·8222	84·8244	84·8267	84·8289	84·8312	84·8334
181	84·8357	84·8379	84·8401	84·8424	84·8446	84·8468	84·8490	84·8513	84·8535	84·8557
182	84·8579	84·8601	84·8623	84·8645	84·8667	84·8689	84·8711	84·8732	84·8754	84·8776
183	84·8798	84·8819	84·8841	84·8863	84·8884	84·8906	84·8927	84·8949	84·8970	84·8992
184	84·9013	84·9035	84·9056	84·9077	84·9099	84·9120	84·9141	84·9162	84·9184	84·9205
185	84·9226	84·9247	84·9268	84·9289	84·9310	84·9331	84·9351	84·9372	84·9393	84·9414
186	84·9435	84·9456	84·9476	84·9497	84·9518	84·9538	84·9559	84·9580	84·9600	84·9621
187	84·9641	84·9662	84·9682	84·9702	84·9723	84·9743	84·9763	84·9784	84·9804	84·9824
188	84·9845	84·9865	84·9885	84·9905	84·9925	84·9946	84·9966	84·9986	85·0006	85·0026
189	85·0045	85·0065	85·0085	85·0105	85·0125	85·0145	85·0165	85·0185	85·0204	85·0224
190	85·0244	85·0263	85·0283	85·0303	85·0322	85·0342	85·0361	85·0380	85·0400	85·0419
191	85·0438	85·0458	85·0477	85·0496	85·0515	85·0535	85·0554	85·0573	85·0592	85·0611
192	85·0630	85·0650	85·0669	85·0687	85·0706	85·0725	85·0744	85·0763	85·0782	85·0801
193	85·0820	85·0838	85·0857	85·0876	85·0895	85·0913	85·0932	85·0951	85·0969	85·0988
194	85·1006	85·1025	85·1043	85·1062	85·1080	85·1099	85·1117	85·1136	85·1154	85·1172
195	85·1190	85·1208	85·1227	85·1245	85·1263	85·1281	85·1299	85·1317	85·1335	85·1353
196	85·1371	85·1389	85·1407	85·1425	85·1443	85·1460	85·1478	85·1496	85·1514	85·1531
197	85·1549	85·1567	85·1584	85·1602	85·1619	85·1637	85·1654	85·1672	85·1689	85·1707
198	85·1724	85·1741	85·1759	85·1776	85·1793	85·1810	85·1827	85·1844	85·1862	85·1879

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TABLE III.—*continued.*

Inclination and Velocity Table. $\frac{d^2}{w}\ D = D_V - D_v$.

v.	0	1	2	3	4	5	6	7	8	9
f. s.	degs.	degs.	degs.	degs.	degs.	degs.	degs.	degs.	degs.	degs.
199	85·1896	85·1913	85·1930	85·1947	85·1964	85·1981	85·1998	85·2014	85·2031	85·2048
200	85·2065	85·2081	85·2098	85·2115	85·2131	85·2148	85·2165	85·2181	85·2198	85·2214
201	85·2231	85·2247	85·2264	85·2280	85·2296	85·2313	85·2329	85·2346	85·2362	85·2378
202	85·2394	85·2411	85·2427	85·2443	85·2459	85·2476	85·2492	85·2507	85·2524	85·2540
203	85·2556	85·2572	85·2588	85·2604	85·2620	85·2635	85·2651	85·2667	85·2682	85·2698
204	85·2714	85·2729	85·2745	85·2760	85·2776	85·2791	85·2807	85·2822	85·2838	85·2853
205	85·2868	85·2884	85·2899	85·2915	85·2930	85·2945	85·2960	85·2975	85·2990	85·3005
206	85·3020	85·3035	85·3051	85·3066	85·3081	85·3095	85·3110	85·3125	85·3140	85·3155
207	85·3170	85·3184	85·3199	85·3214	85·3229	85·3244	85·3258	85·3273	85·3287	85·3302
208	85·3316	85·3331	85·3345	85·3360	85·3373	85·3388	85·3403	85·3417	85·3431	85·3446
209	85·3460	85·3474	85·3488	85·3503	85·3517	85·3531	85·3545	85·3559	85·3573	85·3587
210	85·3601	85·3615	85·3629	85·3643	85·3657	85·3671	85·3685	85·3698	85·3712	85·3726
211	85·3740	85·3754	85·3767	85·3781	85·3795	85·3808	85·3822	85·3836	85·3849	85·3863
212	85·3876	85·3890	85·3903	85·3917	85·3930	85·3943	85·3957	85·3970	85·3983	85·3996
213	85·4010	85·4023	85·4036	85·4049	85·4063	85·4076	85·4089	85·4102	85·4115	85·4128
214	85·4141	85·4154	85·4167	85·4180	85·4193	85·4206	85·4219	85·4232	85·4245	85·4258
215	85·4271	85·4284	85·4297	85·4309	85·4322	85·4335	85·4348	85·4360	85·4373	85·4385
216	85·4398	85·4411	85·4423	85·4436	85·4448	85·4461	85·4473	85·4485	85·4498	85·4510
217	85·4523	85·4535	85·4547	85·4560	85·4572	85·4584	85·4597	85·4609	85·4621	85·4633
218	85·4645	85·4658	85·4670	85·4682	85·4694	85·4706	85·4718	85·4730	85·4742	85·4754
219	85·4766	85·4778	85·4790	85·4802	85·4814	85·4825	85·4837	85·4849	85·4861	85·4873
220	85·4885	85·4896	85·4908	85·4920	85·4932	85·4943	85·4955	85·4967	85·4978	85·4990
221	85·5001	85·5013	85·5024	85·5036	85·5047	85·5059	85·5070	85·5082	85·5093	85·5105
222	85·5116	85·5128	85·5139	85·5150	85·5162	85·5173	85·5184	85·5195	85·5207	85·5218
223	85·5229	85·5240	85·5251	85·5262	85·5273	85·5285	85·5296	85·5307	85·5318	85·5329
224	85·5340	85·5351	85·5362	85·5373	85·5384	85·5394	85·5405	85·5416	85·5427	85·5438
225	85·5449	85·5460	85·5470	85·5481	85·5492	85·5502	85·5513	85·5524	85·5534	85·5545
226	85·5556	85·5566	85·5577	85·5588	85·5598	85·5609	85·5619	85·5630	85·5640	85·5651
227	85·5661	85·5672	85·5682	85·5693	85·5703	85·5713	85·5724	85·5734	85·5744	85·5755
228	85·5765	85·5775	85·5785	85·5796	85·5806	85·5816	85·5826	85·5836	85·5846	85·5856
229	85·5866	85·5876	85·5886	85·5896	85·5906	85·5916	85·5926	85·5936	85·5946	85·5956
230	85·5966	85·5976	85·5986	85·5996	85·6006	85·6015	85·6025	85·6035	85·6045	85·6055
231	85·6064	85·6074	85·6084	85·6094	85·6103	85·6113	85·6123	85·6132	85·6142	85·6151
232	85·6161	85·6171	85·6180	85·6190	85·6199	85·6209	85·6218	85·6228	85·6237	85·6247
233	85·6256	85·6265	85·6275	85·6284	85·6294	85·6303	85·6312	85·6321	85·6331	85·6340
234	85·6349	85·6358	85·6367	85·6377	85·6386	85·6395	85·6404	85·6413	85·6422	85·6431
235	85·6441	85·6450	85·6459	85·6468	85·6477	85·6486	85·6495	85·6504	85·6513	85·6522
236	85·6531	85·6540	85·6549	85·6558	85·6566	85·6575	85·6584	85·6593	85·6602	85·6611
237	85·6619	85·6628	85·6637	85·6646	85·6654	85·6663	85·6672	85·6680	85·6689	85·6698
238	85·6706	85·6715	85·6724	85·6732	85·6741	85·6749	85·6758	85·6766	85·6775	85·6783
239	85·6792	85·6800	85·6809	85·6817	85·6826	85·6834	85·6843	85·6851	85·6859	85·6868
240	85·6876	85·6885	85·6893	85·6901	85·6909	85·6918	85·6926	85·6934	85·6942	85·6951
241	85·6959	85·6967	85·6975	85·6984	85·6992	85·7000	85·7008	85·7016	85·7024	85·7032
242	85·7041	85·7049	85·7057	85·7065	85·7073	85·7081	85·7089	85·7097	85·7105	85·7113
243	85·7121	85·7129	85·7136	85·7144	85·7152	85·7160	85·7168	85·7176	85·7184	85·7192
244	85·7200	85·7207	85·7215	85·7223	85·7231	85·7239	85·7246	85·7254	85·7262	85·7270
245	85·7277	85·7285	85·7293	85·7301	85·7308	85·7316	85·7324	85·7331	85·7339	85·7346
246	85·7354	85·7362	85·7369	85·7377	85·7384	85·7392	85·7399	85·7407	85·7114	85·7422
247	85·7429	85·7436	85·7444	85·7451	85·7459	85·7466	85·7474	85·7481	85·7488	85·7496
248	85·7503	85·7510	85·7517	85·7525	85·7532	85·7539	85·7547	85·7554	85·7561	85·7568
249	85·7575	85·7583	85·7590	85·7597	85·7604	85·7611	85·7618	85·7626	85·7633	85·7640

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CHANGES IN THE ROYAL ARTILLERY.

A

CHRONOLOGICAL SUMMARY

OF THE

HISTORY OF THE REGIMENT.

BY

CAPTAIN R. H. MURDOCH, R.A.,

ASSISTANT SUPERINTENDENT R.A. RECORDS.

[Owing to the necessarily large size of this contribution, it has been thought advisable not to bind it in the number.—*H.W.L.H.*]

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MEMOIR

OF

GENERAL SIR EDWARD SABINE, F.R.S., K.C.B.

THE late Sir Edward Sabine was fourth son of Mr. Joseph Sabine, of Tewin, in Hertfordshire. His grandfather, "The Hon. Joseph Sabine, Esquire, General of Foot, Colonel of Her Majesty's Own Royal Regiment of Welsh Fusiliers," as his monument records, after serving in all the memorable campaigns of King William and Queen Anne, was rewarded with the Government of Gibraltar, where he died on the 24th October, 1739. His uncle, Joseph Sabine, a Captain in the Welsh Fusiliers, was killed at the Battle of Fontenoy. A large old-fashioned seal-of-arms which he was wearing at the time was, many years afterwards, picked up by a member of the family at a shop in some small town in Flanders or Germany, and thus reverted to their possession.

Edward Sabine himself was born in Dublin on 14th October, 1788, and obtained his first commission at the early age of fifteen years and two months, in December, 1803, after a little over ten months as a Cadet at Woolwich. He was one of 27 young Officers commissioned in that month to meet the rapid augmentation of the Regiment, and following 21 who were commissioned in September. So urgent was the occasion that the Professors and Masters were called on to forego their usual vacation to forward the public service.

After a year at Woolwich he proceeded to Gibraltar, and returning in 1807 was appointed to the Horse Artillery, in which he served at various home stations until the end of 1812. On his promotion in January, 1813, he fell to a Company in Canada, and it was on his voyage to Halifax in the *Manchester*, Falmouth Packet, that he had the first opportunity of showing how gallant a spirit was to be afterwards diverted from the pursuit of military distinction into other channels. The *Manchester*, when eight days out, was attacked by one of those American privateers, which swarmed at that period to such an extent that they captured one out of every four of the Falmouth Packets in 1812. After a running fight of twenty hours, and a close engagement of over an hour, she had to strike her colours to greatly superior force, on the 24th June in Lat. 47° 10′, Long. 24° 10′. The privateer was the *York Town*, Captain Rider, a cut-down East Indiaman of 500 tons, carrying nine long 12-prs. and a crew of 116 men, of whom 36 acted as marines. The *Manchester* had only three 9-pr. carronades, two long and two light 6-prs., with a crew of only 36 men, including

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passengers, and only two could be spared to return the musketry fire of the enemy. That an obstinate resistance was offered with such disparity of strength, that the British packet fought until she had only 10 lbs. of powder left, and the 9-prs. were reduced to firing 6-pr. case shot, those guns being disabled, was pre-eminently due to the gallantry of Captain Sabine seconding her Commander, Captain Elphinstone. "Captain Sabine and his servant" (a gunner of the old "school) "were of the greatest assistance to me," wrote the Commander, "and the enemy has confessed that my stern chases, which were "pointed by Sabine and a Mr. Bell, passenger, so compleatly annoyed "them, and did them so much damage that, although greatly our "superiors in sailing, they were loath to range along-side." Sabine himself wrote a detailed account of the action, in which he observed: "We had the satisfaction to find that, notwithstanding the difference "of metal, the *York Town* had received as much material injury as the "*Manchester*, her foremast and foretop-gallant-mast being shot through, "and her hull much damaged, the *Manchester's* mainmast and maintop-"mast were struck in several places, and scarcely a rope left whole in "the ship, the grape-shot and musquetry having been very heavy, "especially at the close of the action when we neared one another. The "enemy fired high, and our bulwarks were very good, which accounts "for only three men being wounded—two with grape, and one by a "musquet shot. The *York Town's* bulwarks were 14 inches solid timber, "which formed a protection for their men which it was scarcely possible "for our shot to penetrate. We knew, however, that one man was "wounded, by the doctor's acknowledgment, and had reason to suppose "that there were more, from an observation of the Lieutenant: 'That "three or four young hands had fancied themselves hurt.' We were "repeatedly told both by the officers and crew of the privateer that they "wished we had never fallen in with them, both in consequence of the "expenditure of powder and shot, and of the injury done to their fore-"mast. We fired above 400 rounds. They must have fired many "more." He mentions that every gun of the enemy was loaded with a *double-headed* shot and a bag containing 60 grape shot.

The Americans behaved very well. Sabine commended their discipline. They respected private property, and treated their prisoners with every respect. The master, mate, and crew were transferred a couple of days later to another prize. The Captain and passengers remained on board, in charge of a prize-master, and with a crew of seven men set sail for New York. As good fortune would have it, they fell in with the *Maidstone* Frigate on Sunday, 18th July, and were recaptured; the privateer herself having been taken by the *Maidstone* on the previous day. Thus this little episode came to an end. Instead of being landed prisoners at New York, Sabine and his companions were set on shore at Halifax, his port of destination, and after a week's delay he was sent round to Quebec. In these days of well-appointed troopships, the faculties of forethought and self-reliance called into exercise by the old hired transport are in danger of being weakened by non-exercise. "These are very uninteresting seas," wrote Sabine: "I have fortunately an excellent stock of provisions, and Smith (his

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"soldier-servant) might *almost* cook for the Regent. My only amuse-
"ment is catching cod-fish. My fellow passenger is too pretty to be
"sensible. The wind and tide are right against us." However, he reached Kamouraska on the 19th day from Halifax, and proceeded by calash to the capital, which made an indifferent impression upon him. "If the fortifications disappointed me, much more the town; a more "wretched, narrow, filthy place I have rarely seen."

It was during his service at Quebec in the winter of 1813 – 14, that an incident occurred, which Sabine was fond of quoting in later life, in illustration of the value of sometimes thinking for one's self. Among the little frontier operations of 1814, was an advance of some American Militia on Quebec; and he was sent with a small party to garrison an out-post. He was directed to take a 4-pr. gun with him; but finding in the Arsenal a light 24-pr. howitzer, which had been left there by General Burgoyne when he went on the Saratoga Expedition, he thought he could manage to transport that; and with or without permission he did so. He found some coehorn shells, and took those, and a supply of fuzes. It is amusing to add that he apparently thought he was making shrapnels of the common shells by putting bullets into them. At any rate, he reached his blockhouse before the Americans, under a Colonel Williamson, appeared: and, arriving in the evening, were settling their camp and busy about cooking, when, to their great astonishment, one of these extemporized shrapnels was fired at them with considerable effect. They forthwith retreated to, what they thought, a safe distance; but another shell burst among them, and seemed to throw them into great confusion. They still further retreated, until fairly out of range. In the morning, when Colonel Williamson ordered them to advance to attack the post, a man stepped forward and told him he would do no such thing, but intended to return home immediately. He was ready to fight to the death in defence of his own country; but he did not see the sense of invading that of others when they had enough of their own. The Commander ordered him to be arrested; but, to his dismay, no one obeyed the order; and when he threatened them, they said they had all agreed with the spokesman, and would go home—and so they did.[1]

Captain Sabine's next service was on the Niagara frontier, where he was favourably mentioned in despatches[2]; and was one of the officers

[1] Captain Sabine learned these details afterwards in New York, from some of the officers present.

[2] LIEUT.-GENERAL GORDON DRUMMOND TO H.E. SIR GEORGE PREVOST.

"To Major Phillot, commanding royal artillery, and Captain Sabine who commanded the "battery as well as the field guns, and to the officers and men of that valuable branch of the "service serving under them, I am to express my entire approbation of their skill and exertions. "Lieutenant Charlton, royal artillery, entered the fort with the centre column, fired several rounds "upon the enemy from his own guns, and was wounded by the explosion."

(Signed) GORDON DRUMMOND, LIEUT.-GENERAL.

To H.E. SIR GEORGE PREVOST. *London Gazette, 11 Oct. 1814.*

The explosion was that of a large quantity of ammunition "by which almost all the troops "which had entered the place were dreadfully mangled;" they numbered 434, who were returned "as 'missing." Captain Sabine was again mentioned for his zeal and exertions, with Major Phillot and Captain Walker, in a despatch dated 19 September, *London Gazette, 19 November.* The artillery lost but one man killed on the two occasions, four wounded and eleven missing.

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privileged to wear the word "Niagara" on his dress and appointments, until our "Ubique" superseded all other badges. He was present at the attack on Fort Erie, on 15th August, 1814, a small affair in the military history of that period, but one which cost the British 27 officers and 326 men killed or wounded.[1] He was also, probably, present in the action of 17th September, on an attempted sortie of the Americans from the same Fort, when our losses amounted to 20 officers and 270 men. Of these actions, the papers to which the writer has had access give no particulars. The Americans evacuated the Fort on the 5th November.

On the termination of the war Captain Sabine was ordered home. The early age at which he obtained his first commission, makes it very unlikely that he owed his knowledge of Practical Astronomy to the Royal Military Academy. In all probability he acquired it at sea, in days when the sextant was more relied on than it is now for the navigation of a ship: certain it is that his reputation as a skilful observer was such that the President and Council of the Royal Society recommended him, in 1818, for the appointment of Astronomer to accompany the Expedition, sent in search of a north-west passage, under Commander John Ross in that year; and from henceforth, although he had short intervals of military duty, chiefly on the Staff in Ireland, down to 1839, his activity was almost exclusively devoted to science. Like his contemporary, Colonel Martin Leake, the one in classical literature, the other in physical science, he gave evidence that a period of most depressing slowness of promotion, and of general stagnation in the atmosphere of Woolwich, could not extinguish the fire of ambition in every breast, or close every avenue to distinction.

Sabine's nomination is in these words:—"Ordered that a letter be written by the Secretary to Mr. Barrow, Secretary to the Admiralty, for the information of their Lordships, inclosing a list of instruments, recommended by the Council of the Royal Society, for the use of the two Northern Expeditions; and the recommendation of the Council of Captain Sabine as a proper person to conduct the experiments on board one of the vessels."—*Min. of Council of Rl. Soc., 29 Jan., 1818.*

Ross's instructions from the Admiralty were somewhat more specific. "We have also, at the recommendation of the President and Council of the Royal Society, ordered to be received on board the *Isabella*, Captain Sabine, of the Royal Artillery, who is represented to us as a gentleman well skilled in Astronomy, Natural History, and various branches of knowledge, to assist you in making such observations as may tend to the improvement of Geography and Navigation, and the advancement of science in general." Unfortunately a misunderstanding occurred. When applied to at the end of the voyage for his reports and drawings, Captain Sabine's answer was:—

DEAR SIR,

In reply to your request for information on Natural History, I have no pretension to more than a very ordinary knowledge of any branch of it, excepting ornithology.

EDWARD SABINE.

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[1] This is from official returns. Sir J. Carmichael Smyth says 905 officers and men, killed, wounded, and missing; and on the second occasion he places the total loss at 609.

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To a further request for specimens, his answer was :—

DEAR SIR,

In reply to your note, the specimens of Natural History being now at the British Museum, I am in almost daily habits of communication with Dr. Leach, to whom I can supply all the information that my notes, which are very rough, and my memory can furnish.

EDWARD SABINE.

Captain John Ross, K.S., R.N.

It is needless to add that the Navigator and the Astronomer had not pulled together, and if half the stories that were current respecting the sayings and doings of the former had any historical foundation, it would have been surprising if they had. Possibly also the *Larus Sabini*, a new species of gull killed by Sabine on the West Coast of Greenland, might then have appeared as *Larus Rossi*, it was described and figured by Joseph Sabine (Sir E. Sabine's brother), in the "*Transactions of the Linnean Society*," Vol. XII. (1819). The report which was not forthcoming to the Commander of the Expedition, appeared in the same volume, and embraced 28 species of birds of Greenland, four of them new to the list, and one not described before by any Naturalist.

This publication was followed by an account of the Esquimaux, who inhabit the West Coast of Greenland, in the "*Quarterly Journal of Science*," 1819.

Annexed to the appointment of Astronomer was an honorarium of £500: and as a great interest must ever attach to the first great Polar voyage of our century—the first indeed since the one in which Midshipman Horatio Nelson, as every British schoolboy knows, or ought to know, won his first victory over a white bear—the subjoined letter, which shows on what grounds it was recommended by the Royal Society to the Government, will be read with interest :—

20 November, 1817.

MY LORD,

It will, without doubt, have come to your Lordship's knowledge that a considerable change of climate, inexplicable at present to us, must have taken place in the Circumpolar Regions, by which the severity of the cold that has for centuries past inclosed the seas in the high Northern Latitudes in an impenetrable barrier of ice, has been during the last two years greatly abated.

Mr. Scoresby, a very intelligent young man, who commands a whaling vessel from Whitby, observed last year that 2000 square leagues of ice, with which the Greenland Seas between the Latitudes of 74° and 80° N. have been hitherto covered, has in the last two years entirely disappeared.

The same person who has never been before able to penetrate to the westward of the Meridian of Greenwich in these Latitudes, was this year able to proceed to 10° 30′ W., where he saw the Coast of East Greenland, and entertained no doubt of being able to reach the land, had not his duty to his employers made it necessary for him to abandon the undertaking.

This, with information of a similar nature derived from other sources; the unusual abundance of Ice Islands that have during the last two summers been brought by currents from Davies' Straits into the Atlantic. The ice, which has this year surrounded the Northern Coast of Ireland in unusual quantity and remained there unthawed till the middle of August, with the floods which have during the whole summer inundated all those parts of Germany, where rivers have

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their sources in snowy mountains, afford ample proof that new sources of warmth have been opened and give us leave to hope that the Arctic Seas may, at this time, be more accessible than they have been for centuries past and that discoveries may now be made in them, not only interesting to the advancement of Science, but also to the future intercourse of mankind and the commerce of distant nations.

The Prince Regent's Government has already given abundant proof of its disposition to follow up the plan of prosecuting discoveries for the extension of useful knowledge and the general benefit of mankind (which has so eminently distinguished the reign of his present Majesty). We cannot therefore entertain a doubt that it will be ready to avail itself of the favourable opportunity which now appears to have occurred, to endeavour to correct and amend the very defective geography of the Arctic Regions, more especially on the side of America. To attempt the circumnavigation of old Greenland if an Island or Islands, as there is reason to suppose, to prove the existence or non-existence of Baffin's Bay, and to endeavour to ascertain the practicability of a passage from the Atlantic to the Pacific Ocean, along the Northern Coast of North America. These are objects which may be considered as peculiarly interesting to Great Britain, not only for their proximity and the great national advantages which they involve, but also for the marked attention they called forth, and the discoveries made in consequence thereof, in the very earliest periods of our foreign navigation.

We have been induced to take the liberty of making this communication to your Lordship, on finding, by a reference to our Minutes, that the Voyage of Discovery towards the North Pole, which was entrusted to the late Captain Phipps, afterwards Lord Mulgrave, was first suggested by the President and Council of the Royal Society, in a communication made to Lord Sandwich, then First Lord Commissioner of the Admiralty, on the ground that such a voyage might be of service to the promotion of Natural Knowledge, which is the proper object of this Institution, under the patronage of His Majesty. We therefore beg leave, in the event of one or more expeditions being fitted out on the present occasion, to make an offer of our services in any way that may be thought useful in the preparation thereof, or conducive to the accomplishment of the objects which such expeditions may have in view.

(Signed) JOSEPH BANKS, *President, R. S.*

To The Right Hon. The Viscount Melville.

Sabine was not allowed to be idle long. On the equipment of a second Polar Expedition, under Lieutenant-Commander Edward Parry, in 1819, he was again selected to accompany it.

Parry, in the introduction to his Journal, published 1821, acknowledges Sabine's labours in these terms :—

"The various observations made on board the *Hecla* during the voyage have been carefully collected into tables, on the model of those of Wales and Bayly, by Captain Sabine, to whom I am indebted for the arrangement of nearly the whole of the Appendix, and for the superintendence of that part of the work during its progress through the press. I feel it no less a duty than a pleasure to acknowledge that in the performance of this task, Captain Sabine has added another to the many obligations I owe him for his valuable advice and assistance during the whole course of this voyage, to the credit of which, his individual labours have so essentially contributed."

It might have been added that he contributed not a little to the

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cheerfulness and harmony of the expedition, by consenting to edit the "*North Georgia Gazette and Winter Chronicle*," a weekly publication established during its tedious stay at Winter Harbour, when the sun was 96 days below the horizon. It extended to 21 issues. The total strength of Officers of the Expedition being but 18, including the Midshipmen, the Editor had to rely very much on his own pen. It was kept up with spirit; the verse is more humorous than the prose, and both have lost their sparkle perhaps, but it owes its prevailing good humour, and the total absence of personality, entirely to the Editor's good taste, tact and firmness. It never attempted to be instructive; every little incident is made laborious fun of, imaginary advertisements offered a wide field; and on the whole, partly from the novelty of the effort, it was so highly appreciated as to call for re-publication.

Sabine did not accompany Parry on his second voyage; the post of Chaplain and Astronomer being filled by the Rev. George Fisher. He was himself selected for a far higher office; namely, to conduct a series of experiments for determining the variation in the length of the pendulum vibrating seconds, in different latitudes, with a view to ascertain the true figure of the earth, a subject which had engaged his attention in the first voyage. He communicated a paper on it to the Royal Society in 1821, which contributed to procure him the honor of the Copley Gold Medal in that year. At that time the ellipticity generally accepted, on the high authority of La Place, was $\frac{1}{305}$, and it was with no little surprise that he found on arriving at Sierra Leone, that the results he obtained would not accord with that theory. The retardation was several seconds less than he anticipated, proving the ellipticity to be greater; ultimately, the value which he obtained and published in 1825 was $\frac{1}{288\cdot4}$, which is almost identical with the final result from all the pendulum experiments made since. Colonel Andrew Clarke, R.E., assigns $\frac{1}{288\cdot5}$, in the last edition of the *Encyclopædia Britannica* (1877).

Sabine in the pursuit of this investigation, visited St. Thomas, Maranam, Ascension, Sierra Leone, Trinidad, Bahia, Jamaica in 1821–22; New York, Drontheim, Hammerfest, Greenland and Spitzbergen in 1823. No less than five men of the Royal Marines, who had been placed at his disposal by Captain Clavering, R.N., as assistants at Sierra Leone, were carried off by fever during a stay of about five weeks in that pestilential climate.

The remarkable account of his experiments, printed in a 4-to volume by the Board of Longitude in 1825, must always remain an enduring monument to his scientific merit. It would be impossible in this brief notice to give any adequate idea of the indefatigable industry, the spirit of enquiry, or the range of observation evinced. It appears, indeed, as if he had desired to emulate A. von Humboldt, to whose earlier writings he acknowledges his obligations for awakening in his mind a taste for pursuits, which formed a large portion of his interest, and added so greatly to his enjoyment of life.[1] The work was honored by the Lalande Gold Medal of the *Institut de France* in 1826: and the

[1] Editor's preface to Cosmos, Mrs. Sabine's translation, 1846.

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same year witnessed an event of far greater moment, in his happy union with Miss Elizabeth Juliana Leeves, daughter of William Leeves of Tortington, thenceforth his inseparable companion, his invaluable and devoted assistant, latterly his vigilant guardian, until their union was dissolved by her death in 1879, after 53 years of married life.

It is not for the present writer to attempt to pourtray this bright and gifted lady, who, had she not with a rare self negation, sunk her individuality in his, might have made for herself a name, as one of the remarkable women of her day. Her mastery of the German language was something exceptional. Sir John Herschel, no mean judge, considered it to surpass his own. She made herself competent to share in every investigation her husband undertook, and habitually examined and checked his work; suffice it to say that thenceforward his powers were doubled.

Captain Sabine's next service, after the publication of his Pendulum Experiments, was as a Joint Commissioner, in 1825, with Sir John Herschel, to take part with a Commission, nominated by the French Government, to determine the precise difference of Longitude between the Observatories of Paris and Greenwich, by means of rocket signals. Herschel and M. Largeteau were the observers on the French side of the Channel at Lignieres, Captain Sabine and Colonel Bonne on the British side at Fairlight Downs, near Hastings. The difference of Longitude thus found was 9m. 21·6s., which was believed to be not more than one-tenth of a second in error, and extremely unlikely to prove erroneous to twice that amount. The accepted difference at the present day of electrical signalling is 9m. 21·0s., a slightly larger error, but the determination was very close. In 1827, he compared the length of the seconds pendulum and the magnetic force of the earth at the same two stations.

Having obtained from the Duke of Wellington, then Master-General of the Ordnance, a general leave of absence from Military duties as long as he could be usefully employed in scientific pursuits; he became in 1827, one of the Secretaries to the Royal Society, which office he filled down to 1829. These years were productive of several papers, chiefly on Magnetism and Geodesy.

It would not be doing justice to Captain Sabine, however, to attribute his almost exclusive addiction to physical science at this time, to want of interest in Military subjects, and in the scientific branches of his own profession. The cause is rather to be found in the suspended animation of the latter during the dreary period which succeeded the Peninsular War, and the general absence of any interest in, or appreciation of such pursuits on the part of the majority of those gallant soldiers, whom the Great Duke had led to victory, and who, because the British Artillery was justly acknowledged to be the first in Europe, could not perceive the necessity for advancing with the times. The obsolete mechanical processes of the Royal Arsenal, where the boring mills continued to be turned by horse power, as they were a century before, down to the year 1841, reflected not only the poverty of the Exchequer and the economy of the Board of Ordnance, but also the

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want of any encouragement to activity, and of any consciousness of defect in the representative Ordnance Authorities of the day.

Captain Sabine showed by his review of the first number of the *Memorial de l'Artillerie*, which extends to 21 pages of the *Quarterly Journal of Science* (1827), a high appreciation of the encouragement given by the French Government, in 1824, to the cultivation of Artillery science, by the establishment of three annual prizes (one of 1500 and two of 1000 francs each), to be given "to officers who, "in the course of the year, shall have presented views or discoveries "useful in one of the branches of the service of the Artillery: or "who shall have resolved with success the questions which the "Central Committee, viewing the points of the service to which it is "most desirable that the attention of officers should be directed, "shall have proposed as subjects for their consideration."

He analyses the paper on "Ricochet Fire," by Lieut.-Colonel Lyautey, to which the first prize was awarded, and dwells on the value of that feature of the work, as yet unknown to the British Artillery, which consisted in the publication of changes of the *matériel*. Like many of his papers it is only initialled E. S.

On the abolition of the Board of Longitude, in 1828, it was determined that three appointments originally given to "three persons well "versed in the sciences of Mathematics, Astronomy, or Navigation, "as a Resident Committee of the Board," should be continued to three "scientific advisers of the Admiralty," each of them receiving £100 a year: the selection was limited to the Council of the Royal Society, and as the appointment to the Council was virtually in the hands of the President, the arrangement was fiercely, and not without apparent reason, denounced as a job. Herschel and Kater, members of the former Committee, declined; Sabine, Faraday, and Young were appointed. This circumstance brought down upon the head of the former a violent personal attack, by Charles Babbage, in a work entitled "Reflections on the Decline of Science in England, and on some of its causes." (1830). Briefly, the alleged causes were favouritism and inefficiency in the Council of the Royal Society, exclusion of talents of the highest order—especially mathematical talent—from that body, by the jealousy of mediocrity, and absence of adequate encouragement to scientific men from the government of the country. In Sabine's case the point of the attack lay in the alleged *impossible* accuracy of his published observations. It would be as ungracious, as useless, to revive this forgotten controversy. The late Dr. T. R. Robinson, of Armagh, a most distinguished Astronomer, told the present writer, in 1857, that Sabine, being then on the Staff in Ireland, smarting under the implied accusation, placed his rough notes in his hands, and entreated him to subject them to the closest scrutiny: feeling much sympathy for him, he did so; and found that far from being *sur-humaine*, as Biot declared them, they were rather indifferent observations[1]. The appearance of extreme accuracy was given, as the

[1] M. Biot bore no love to Sabine, who had pointed out in his account of "Experiments to determine the Figure of the Earth," (p. 462), that the theory of Terrestrial Magnetism, which he had advanced in his "*Précis de Physique Expérimentale* (1821), could not be reconciled with the facts observed. He had, in fact, found the Dip to be only 80°, where the distinguished French philosopher proved that it ought to be 90°.

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writer understood, by, in some way, presenting averages, so that they were mistaken for individual results. Certain it is that he retained the firm friendship of Dr. Robinson to the end of his life—a result not consistent with the detection of any inadmissible manipulation of his figures. There is no reason why Sabine should not have been an observer of more than ordinary skill and dexterity, and many reasons why it is probable that he was. His keen eye, light, active, and nervous figure, extreme intelligence and vivacity of temperament, and immense practice, were highly favourable to that result. It was something more than happy chance which made Captain Duperry, the French Navigator, in 1825, fix the Longitude of Ascension within 21″ of what Sabine had made it by innumerable lunars in 1822; at the same time there were circumstances which perhaps justified mistrust. Sabine did not condescend to answer the attack, but contented himself by inserting an explanation in the *Philosophical Magazine* for 1830, on one point which had been particularly laid hold of. It is of course not contended that Sir E. Sabine was a mathematician in the sense in which Mr. Babbage understood the term. He often had recourse to real mathematicians, such as Provost Lloyd, of Trinity College, Dublin, or Mr. Archibald Smith, for original investigation, but he was a competent master of applied mathematics, particularly in the class of problems concerned in deducing mean results from numerous observations, which require extraordinary care in their solution; and, remembering how early he left the Academy, and how few Officers, at all events in those days, were found to extend their mathematics afterward, he deserved much credit for his attainments, without which, indeed, his pendulums might have swung in vain.

The condition of Ireland in 1830 was, as it has been usually since, one to occasion the gravest anxiety. There was a failure of the potato, from the effects of a cold wet summer; local famines; an epidemic of influenza; constant collisions between the peasantry and the police. Under such circumstances Captain Sabine was ordered to join his Company: he served with it, or occasionally on the Quarter-Master General's Staff, for the ensuing seven years, and acquired the character of being a very "smart officer:" but the time was by no means lost to science. He published two Pendulum papers in 1830 and one in 1831. In 1834 he commenced, in conjunction with the Rev. Humphrey Lloyd (afterwards Provost of Trinity College), and Captain James Clarke Ross, R.N. (afterwards Sir James Ross, of Antarctic fame), the first systematic magnetic survey ever made of the British Islands. He extended it, single handed, to Scotland, in 1836, and to England, in conjunction with the same and some additional observers, in the following year. With the exception of the mathematical section of the Irish Report, which was Professor Lloyd's, the Reports—which were published by the British Association—were mainly his; and also a very large share of the observations, more particularly the laborious task of combining them, by equations of condition, to obtain the most probable mean results. About 23 years later (1858–61), with unabated interest, and still privileged

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to number Dr. Lloyd among his co-adjutors, he undertook, at the request of the General Committee of the British Association, to repeat this Survey; and, as before, reduced and reported the results, as far as concerned the elements of Dip and Force. Captain (now Sir F.) Evans, R.N., Hydrographer to the Admiralty, dealt with the Declination.

The year 1836 will ever be memorable in the history of British Science, for a letter, dated 22 April, addressed to H.R.H. the Duke of Sussex, President of the Royal Society, by Baron Alexander von Humboldt, in which he urged upon the British Government to establish regular magnetical stations in different parts of the British Empire, similar to those which, mainly through his influence and exertions, had already been some years in operation in Northern Asia. This letter was referred to the Astronomer Royal, Mr. (now Sir George) Airy, and Samuel Hunter Christie[1] for a report, which will be found in the *Proceedings of the Royal Society*, Vol. III. The pear was now ripe; the Society threw its whole weight into the scale; and probably no busier years were ever known in Somerset House, where the Society had its apartments, than the next three. A Committee on Mathematics and Physics was appointed in May, 1838, of which Major Sabine[2] and Lieut. (the late Sir William) Denison, R.E., were members, and towards the end of the year the definitive and official recommendation was made to H. M. Government, already prepared to receive it, to establish magnetic observations, and despatch a Naval Expedition to the Southern Hemisphere.

It is needless to say that Major Sabine played an active and conspicuous part in all these negotiations and preparatory arrangements, the first of which, as it immediately concerned the Royal Artillery, will be best seen by the subjoined letter addressed to Lieut. (now General Sir) Henry Lefroy:—

April 10, 1839.

My Dear Sir,

The enclosed report and its subjoined letter will make you acquainted with the particulars of the scheme of magnetic research which has been fully acceded to by Government.

You will perceive it consists of two branches; a Naval Expedition, and fixed Observatories at certain stations on land. The Naval Branch is of course under-

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[1] Christie and P. Barlow, both Professors at the Royal Military Academy, devoted much attention to Magnetism, and contributed papers on it to the Royal Society.

[2] Captain Sabine received a Brevet Majority in the usual course of periodical promotion, in January, 1837, and did duty for a short time at Woolwich. In an application for this promotion, dated July 11, 1827, he states, in reference to his first employment: "The application from the "Royal Society was made through the late General Mudge, of the Royal Artillery, Conductor of "the Trigonometrical Survey, and a member of the Board of Longitude; who also conveyed to me "the Master-General's promise, 'that I should receive a step of promotion by brevet, in the event "'of the Naval Officers receiving promotion for that service, and on my recommendation from the "'First Lord of the Admiralty as deserving that indulgence.'" He was accordingly recommended by the First Lord on his return, and his promotion solicited in a special communication from the President and Council to the Duke of Wellington. It was in vain; and to the shame of the Board of Ordnance he could write: "All the Naval Officers employed in the Arctic Expeditions with "myself have been promoted: those of corresponding rank to myself have received two steps of "advanced rank. I have received no recompense in lieu of the promotion that was promised me, "nor distinction of any kind from my own Government, from my first embarkation in the Arctic "Expeditions to the present time."

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taken by the Admiralty, and the ships, or one at least, is this day commissioned. It is the intention of Lord Melbourne that the fixed observatories should be carried into execution by the Ordnance Department, and Sir Hussey Vivian is to be acquainted with this intention to-day. The observatories are to be three in number, Canada, St. Helena, and the Cape of Good Hope; others are to be established by the E. I. Company, and other nations are to be invited to co-operate. The duration of the observatories is not to exceed *three* years, and it is proposed that each should be under the direction of an Officer of Engineers or Artillery with three N.-C. Officers of his choosing. I know not how such employment might be suitable to your wishes, but from conversation I have had with Sir A. Dickson, I think it most probable that he will look to you as the first person whose wishes he will ascertain. I therefore write you this *private* note, to give you a little more time than you might otherwise have for considering the subject, and to offer you any further explanation that you may desire in considering it. The Dublin Observatory (Professor Lloyd's) will be the model on which the fixed observatories will work. The Officers who undertake their charge will have to be instructed there, and you may be quite sure that there will be no part of the duty of which you will not be able to make yourself fully master.

(Signed) EDWARD SABINE.

Lieut. Lefroy's acceptance of this offer was followed by that of Lieut. (late Lieut.-General) F. M. Eardley-Wilmot, and Lieut. (now Major-General) C. J. B. Riddell, and these three Officers formed the first Magnetical Staff, under Major Sabine, who was appointed to superintend the whole. Two years later Lieut. Riddell being invalided home from Canada, Lieut. Lefroy was transferred from St. Helena to succeed him, and his place was taken by Lieut. (now General) W. B. Smythe; about the same time Lieut. (now Lieut.-General) C. Younghusband was attached to the Observatory at Toronto; in 1847 Lieut. H. F. Strange proceeded to St. Helena, and in 1844 Lieut. (now Major-General) H. Clerk was sent to the Cape, whence he sailed the following year to carry out, in the hired barque, *Pagoda*, Lieut. H. E. L. Moore, R.N., in command, an extensive survey of parts of the Antarctic Ocean not visited by the *Erebus* and *Terror*, under Sir James Ross, of which he gave an account in the *Philosophical Transactions* of 1846. Thus it will be seen that, thanks to the strong position attained by his own great abilities, the claim of the Royal Artillery to its reputation as a scientific branch of the Army, which he had indeed sustained almost alone for many years, was fortified by the appointment of no less than seven junior Officers from its ranks, for a scientific purpose, all but one of whom became eventually Fellows of the Royal Society. It would be ungrateful to omit to record how zealously and admirably they were served by the intelligent Non-Commissioned Officers of Artillery, selected as their assistant observers.

Major Sabine was appointed General Secretary to the British Association in 1839, a laborious office which he continued to hold to 1858. In 1846 he became Foreign Secretary to the Royal Society, and in 1850 Vice-President and Treasurer, having received the Royal medal the previous year. The high honour of being elected President of the British Association, in succession to the Astronomer Royal, fell to his lot in 1852; and the yet higher honour of being elected President

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of the Royal Society in 1861; he filled this chair till 1871. He was a member of the principal learned societies and scientific bodies in Europe and America, and was made a K.C.B. in 1869. He received also most of the honors it is in the power of English Universities to confer.

Although it is impossible in the compass of a brief sketch to give even the most concise summary of the scientific results which flowed from his inexhaustible industry, aided by a clerical establishment maintained by Government for 20 years (1841 – 1861) at his exclusive disposal:[1] this memoir may be reasonably expected to devote some space to that portion of them which, from the *personnel* employed, may be represented as a service rendered to science by the Royal Artillery.

The observatories began their work in 1840. The first publication was a 4-to volume of observations on days of unusual magnetic disturbance, published in 1843, which was followed by a second, on the same subject, in 1851 : the introduction to this latter was by Captain Younghusband, then Lieut.-Colonel Sabine's assistant. It would be difficult to specify any important result from the publication of these two volumes, which contain over 550 pages, and cost immense labour: they contain a store of facts of observation, and may possibly be referred to whenever a satisfactory physical theory of terrestrial magnetism shall be suggested; but eye observations at however short intervals are so inferior, in regard to almost every subject of enquiry, to the continuous photographic records now kept in many places, that they are little likely to be studied. This does not prove their publication to have been injudicious. The irregular or disturbed movements of the magnet were at that time very prominent objects of research. Sabine had suggested their investigation as early as 1822. Humboldt and the German observers were warmly interested in them. It was even hoped that they might prove to be sufficiently simultaneous over large parts of the earth's surface to be available for determining differences of Longitude. These hopes have not been realized; and the enquiry as yet has proved rather barren, for want of a key to the phenomena.

The case was very different with the volumes of regular magnetical and meteorological observations, eleven in number—observations made every two hours in 1840 – 41, and every hour after that date. They form but a fractional part of the enormous mass of material of the same description made available to science in the course of the succeeding twenty years : but, from the uniformity of the plan pursued, and the wide distribution of the stations over the globe, must always take a prominent place among the international results. Each of these volumes is preceded by a discussion of its contents by Lieut.-Colonel Sabine, the general Editor. The several Directors of the Observatories had no part allotted to them beyond responsibility for the routine of their establishments, and the arithmetical accuracy of

[1] For 13 years (1841 – 1854) he had the assistance of an officer—first Lieut. Riddell, then Lieut. Younghusband—and four or five military clerks; from 1854 to 1861 of a civil chief assistant (previously one of these N.-C. officers) and four military clerks.

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the returns of Observations transmitted monthly to Woolwich. A great inducement was thus withheld from them to study the subjects with which they dealt, in their higher or general aspects, and their responsibility was lowered. The occasion is never likely to repeat itself; but if it should do so, a greatly modified system should undoubtedly be followed.

General Sabine's introductions to these bulky volumes amount to nearly 800 (4-to) pages, and treat in turn of every subject presented for investigation. The periodical laws governing the observed changes of each of the magnetical elements, and the like for those of meteorology. Their connection with solar physics; the influence of the moon upon them; the laws governing the irregular fluctuations of each element; secular changes; all of these, unequal in different places, and some of them, if not absolutely his discoveries, for the first time worked out fully by him.[1] The activity of mind, and the indefatigable industry evinced by him, the laborious services of his clerical assistants, frequently acknowledged, all come out the more strongly the more these introductions are studied. Let us, for example, suppose the enquiry to be "Whether the daily passage of the moon across the meridian produces any perceptible effect upon the magnetism of the earth:" the method pursued was this:—

Having before him the sheets containing the observations for a whole month, arranged in 24 parallel columns for the several hours, and the means truly taken, about 624 readings for each element, the computer proceeded to take the difference between each individual observation and the mean at the same hour, for the month: all which exceeded a certain arbitrary limit (4 scale divisions), and were regarded as *disturbed*, by the operation of causes unconnected with the moon, were then set aside or lined out, and the observation nearest to the hour of the moon's meridian passage on each day, being marked, all the Remainders were re-written out in 24 columns, corresponding to the intervals of time before and after that passage. This having been done in the case of the declination at Toronto alone for 45,000 observations, it is ultimately ascertained that the north end of the magnet at that station is deflected to the amount of 18·95 secs., when the moon is on the upper meridian, and to the amount of 19·38 secs. when she is on the lower meridian, both to the *east*, also to the amount of 20·21 secs., six hours before her meridian passage, and 18·14 secs., six hours after her meridian passage, both to the *west*. The inclination and the force exhibit corresponding effects, the former three hours later, the latter also three hours later in the post-meridian period, but four hours later in the ante-meridian period.

By a similar method of investigation, Lieut.-Colonel Sabine was able to make an announcement, which was received with much scientific interest in 1852, of a remarkable coincidence between "the periodical "inequality by which the magnetical variations, referable to solar

[1] Thus the lunar effect on the barometer was discovered at St. Helena, by Lieut. Lefroy in 1842, (*see Proceedings, Royal Society, 1842, p. 395*). The lunar effect on the magnetic declination by M. Kiel, at Prague, in 1841, and on the horizontal force by Mr. John Allan Brown, at Makerstoun, in 1844. In both cases the investigation was greatly extended, but not originated, by Sabine.

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"influence, are affected, and the periodical inequality which has been "discovered by M. Schwabe (in 1838) to exist in the frequency and "magnitude of the solar spots."

As we have already observed, the full value of these laborious computations remains to be realized when the nature and extent of the connection between solar and terrestrial physics, and the origin of the earth's magnetical conditions are better understood; they are in the meantime important contributions towards that result.

The dates of these publications were:—

Toronto	to 1842, Vol. I.	1845.
"	to 1845, Vol. II.	1853.
"	to 1847, Vol. III.	1857.
"	The observations from 1848 to 1853 remain in MS.	
St. Helena	to 1843, Vol. I.	1850.
"	to 1849, Vol. II.	1860.
Cape of Good Hope, magnetic ...	to 1846, Vol. I.	1851.
" " meteorological	to 1848, Vol. II.	1880.
Hobarton, Tasmania[1]	to 1842, Vol. I.	1850.
" "	" Vol. II.	1852.
" "	" Vol. III.	1853.

It has been mentioned that the East India Company took a large share in the International enquiry. They established an Observatory at Simla, under Lieut. (now Major General) Theophilus Boileau, Bengal Engineers; one under Lieut. Ludlow, Madras Engineers, at Madras; and another under Lieut. Elliott, also Madras Engineers, at Singapore. Major Sabine had nothing to do with these after the first steps, and their history was disastrous. The original records of Simla were all destroyed by fire in 1858, the cases in which they had been packed for transmission to England, by Colonel Boileau, R.E., on his retirement in 1857, having been transferred during the Mutiny from the safe depository, in which he had placed them, into a store room, which took or was set on fire. He ultimately published the Meteorological Observations from copies in England, in 1872; those of the other two observatories were printed at the American Mission Press, Madras. None of the magnetic observations have as yet been printed, nor were they apparently communicated to Sabine, for he never refers to them.

From these official publications, we pass to Magnetic Surveys. Sir E. Sabine lived to complete in fifteen "Contributions" to the *Philosophical Transactions*, a gigantic work undertaken by him, namely a survey of the general Distribution of Magnetism over the Globe at this epoch. Several of these appeared after he had lost the aid of his establishment of clerks, the last in 1876. In these are to be found every observation of any authority, taken by sea or land, since 1835, or thereabouts,

[1] The observatory at Hobarton was founded by Sir James Ross, R.N., and conducted by Officers of the Royal Navy under Lieut. Kay, R.N.

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arranged in zones of 5° of Latitude, and taken in the order of Longitude round the Globe. All the results of Arctic and Antarctic voyages, Special Expeditions, such as (to name Officers of Artillery only) those of Lefroy, Clerk, Blakiston, Haig. Everything that he could glean from Russian, German, American and other Foreign sources, much of which is not accessible in any other form; and these were accompanied by admirable maps prepared for him in the Hydrographical Department of the Admiralty, under the supervision of Captain (now Sir) Frederick Evans, R.N. It may be safely said that had Sir E. Sabine done nothing but collect, compile and discuss this vast mass of material, he would have rendered a service to science, which would make his name live as long as Halley's—but it forms but a part of his life's labour. Communications to the Royal Society and the Philosophical Magazine, on some subject of the moment, were always pouring from his pen. It has not been attempted to enumerate them. His addresses to the British Association, and the Royal Society, as President, also must not be forgotten. The Royal Society Catalogue of 1870, gives the titles of 90 of his papers, and several appeared after that date: and after his 80th year, more particularly his contributions to Magnetism, Nos. XIII, XIV. and XV. It was not until 1876 that age and infirmities brought his long labours to a close. His latter years, which terminated on 26th June, 1883, at the age of 94 years 8 months, were clouded by that eclipse of the faculties which so often attends the closing scenes of a life prolonged far beyond the ordinary limits of human strength; and his remains were laid beside those of his beloved wife at Tewin on the 30th, in the presence of his nearest relations, together with representatives of the Royal Society, and of the Officers who had served under him.

Sir Edward Sabine's likeness, in the Messroom at Woolwich, taken when he was past 80 years of age, although an excellent work of art, does but imperfect justice to him. There is a much better one at the Apartments of the Royal Society. He has left no descendants, but the Sabine family survives in his nephew, Admiral Sir Thomas Sabine Pasley, R.N. Here must terminate this brief sketch of the life and labour of one of the most remarkable men whom the Artillery has produced. A critical review of the latter belongs to the annals of science—the appreciation of his personal character to those with whom his multiplied activities threw him into close association. Of the Members of the Committee of Physics and Meteorology of 1838, only Sir George Airy survives, and, having outlived nearly all his contemporaries, few of this generation are qualified for the task.

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NOTES

ON

VISITS TO THE MILITARY ACADEMY, WEST POINT, UNITED STATES,

AND TO THE

ROYAL MILITARY COLLEGE OF CANADA.

BY

CAPTAIN G. MACKINLAY, R.A.

The Military Academy, West Point.

Nearly two hours by rail from New York, on the left bank of the Hudson, is the small railway station of Garrisons; a steam ferry meeting each train gives access to the other side of the river, from whence a gentle ascent, about a quarter of a mile long, leads to the elevated plateau on which West Point Military Academy is situated. The river bends round the Point, and rocks, trees, hills, and water combine to make a most lovely site, and this is not spoilt by the Academy, which consists of detached well-built stone buildings harmonising with the surrounding scenery. The country in the neighbourhood being hilly and rocky, and not of much use for agricultural purposes, is only thinly inhabited, and there are hardly any except Government Buildings at the Point; but another line of rail is now being made on the right bank of the river, and it will have a station at West Point close to the Academy; this will probably bring more visitors and inhabitants to the neighbourhood. At present, however, the Academy is much isolated; and this must have an effect on the conduct and character of the Cadets, the more so as many come from distant States and have no friends in New York.

Provided with a letter of introduction to Maj.-Gen. Merritt, the Superintendent, I called on him on 3rd January last. He was most courteous, and took me to the examinations, which were then proceeding. We entered a fine hall decorated with many portraits of former Professors and others, and found some 12 or 15 Cadets of a junior class being questioned in turn in mathematics. Six or seven Officers in full uniform were seated at tables with pen and ink before them, while one of their number in a searching manner questioned a Cadet, who stood at attention at some little distance; this rather gave the idea of a Court-Martial, which was further borne out by the presence of the Cavalry orderly in waiting, and the wording of the official order, which stated that the examinations will be "continued until finished." The Cadets bore themselves well, and gave their answers in a manly straightforward manner. For many years it has been the custom to teach, as well as to examine by *viva voce* questioning before a whole class, and thus, doubtless, confidence is gained by

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practice; sometimes, however, nervousness is manifested; and the General remarked, a brother Officer had once told him, that just before going into action, his feelings reminded him of the West Point examinations, when he was subjected to the ordeal such as that which we were witnessing.

We then passed to a large class room, where more Officers were assembled examining some of the senior Cadets in international law—rather an intricate subject. Here I had the pleasure of being introduced to the Professor of Artillery, who took me to his class rooms, in which were numerous models and specimens of arms, &c., to illustrate the subjects taught. The Artillery Staff consists of three Officers, and the Cadets spend about the same amount of time on this study as our Cadets do at the R. M. Academy; but the Americans have not the advantage of an Arsenal close at hand, where war *matériel* may be seen in the stages of its manufacture. Only a few Cadets are instructed at a time, thus entailing considerable labour on the Officers; but no pains seems to be spared to perform really hard work, not only by the Cadets, but also by the Instructors and Examiners.

A visit was then made to the dining hall—plain but comfortable; to the gymnasium, which is to be enlarged and more used than at present; the bowling alley was also seen,—this furnishes almost the only game which the Cadets have time to play.

After this the Secretary and the Officer on duty took me to see the barrack rooms, which are comfortable apartments with the sleeping part of each in a kind of recess: two Cadets occupy a room. Here was an opportunity of individual conversation with the Cadets themselves, who spoke in a cheery way of the examinations and life in the Academy generally. The course lasts for four years, and it will probably be extended to five years, but a general education is provided as well as a military one. The method of admission is as follows:—each Representative of a State in Congress has the duty of selecting a candidate, when required, from his own State, and but little examination is demanded. Some Representatives give their Cadetships to the best at a competitive examination, but this is not the case generally, though it may perhaps be made the rule in future. On entering the Academy the Cadets are given every facility for learning, but at the end of the first year comes a stiff examination, which many fail to pass, while others again resign beforehand, not feeling prepared for it. More than 50 per cent. of those who enter are sent away for failing to pass examinations, but most of these failures take place in the first year. A good deal is demanded of the Cadets: for instance, each one has to learn the differential and integral calculus, and also to clean his own arms and sweep out his room; military duties such as guard mounting are performed, and the discipline is strict.

The Cadets are dressed in a French grey uniform, their jackets are covered with worsted cross bars, they wear large white turn down linen collars, and they appeared to be fine manly young fellows, of good stature and physique.

There was no opportunity of seeing any drills at the time of my

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visit, as they cannot be carried out during the winter, which is severe. They are, I was told, very thorough; and each Cadet, for whatever branch of the Service, learns the drills and duties of Cavalry, Artillery and Infantry. Camping out is practised each summer. I did, however, witness the daily evening parade: the Cadets fell in by Companies, and wheeled rapidly into line, when the drummers on the right beat the retreat, and a senior Cadet read out a variety of orders and notices—some being charges of minor breaches of discipline against individual Cadets, who had to render a written reply by the next morning. The wonderful steadiness of the line of young Cadets on this routine parade was most striking.

With regard to the Officers, the General spoke of having himself been a Cadet 20 years ago, and the whole of the Staff is composed of West Point graduates, who are justly proud of the Academy, and they possess great *esprit de Corps*.

The Civil War afforded an opportunity to many West Pointers, who rapidly rose to the most important positions of command on both sides; this was doubtless very largely due to the sound military education received in youth. At the present time only a limited number of appointments to the Army are available to those who have passed through the Academy, and some graduates become professors elsewhere, or they take to Engineering.

The Royal Military College of Canada.

THE military spirit of the Canadians has been shewn by the steady development of a Military system, with a large Militia force, since the withdrawal of the Imperial Troops, and a Military College, (the first among the Colonies) modelled partly on English and partly on United States lines, has also been formed to provide well trained Officers. This College claims attention, as four Commissions in our Army are annually granted to senior Cadets—two of whom have already seen active service in Egypt.

The handsome stone buildings of the College, in an enclosure of 65 acres, consist of two main parts; one built by the Imperial Government in 1838 for the Admiralty, called the "Stone Frigate," was altered to serve as barracks for the newly formed College in 1876: the other part, forming the main building, was constructed by the Dominion Government at the opening of the College, and serves as class rooms and offices. The site is a neck of land projecting into the eastern end of Lake Ontario, reached from Kingston by a very long bridge, and it is rather more than a mile from the town. The surrounding country is slightly undulating and fairly open, but the soil is stony and not of much good for farming. The climate is said to be temperate *for Canada*, and the very great extremes met with in other places are not experienced, nevertheless the thermometer ranges from a minimum of 25° (Fah.) below zero in winter, to a maximum of 110° in the shade in summer. At the time of my visit in January last, the country was covered with snow, and it was intensely cold, and although the frost had not been of long

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continuance a considerable part of the Lake was frozen over, necessitating a curious mode of travelling across it to Cape Vincent in the United States. A steamer goes daily when there is no ice, or when it can cut its way through, and when the ice is safe sleighs take passengers across; but at the intermediate times, such as on the day when I crossed, a large boat on runners was hauled along by a horse, so that if the ice gave way the passengers could make use of the floating power of their conveyance; the horse was to be pulled out of the water if he fell through, and for this purpose a rope was ready round his neck. A good margin of time was given to allow for any such accident, and an early start was made, but everything went well, and no opportunity was afforded of seeing the expedients, which could be tried, in case of the breakage of the ice, during a three miles journey; a great part of the way was on ice, which had been broken by the steamer, which had cut its way through on the last day when a passage had been made,—the Canadians said that this was stronger than the surface, which had not been broken; then came a sleigh drive of seven miles across an island, and afterwards about a mile in a boat across water, which for the first 300 yards was packed close with large slabs of ice drifted together, where passengers, as well as boatmen, were required to use boathooks and oars.

Introduced by Captain Douglas Jones, R.A., Professor of Military History, &c., I paid a visit to the College, and called on Colonel E. O. Hewett, C.M.G., R.E., to whom belongs the credit of having organised and conducted the College from its commencement. Of the subjects of which the Commandant spoke, perhaps the most interesting to Artillery Officers was the great skill of the Cadets in Repository exercises; and it so happened that just previous to my visit a report was received of a shift[1] of a gun from one carriage to another in a most rapid manner. The Cadets take the greatest interest in these

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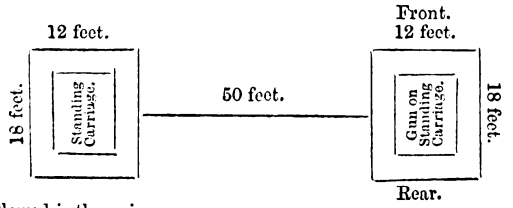
[1] The following is an extract from the order for the competition :—

"CIRCULAR No. 44.—A 24-pr. 50-cwt. gun, mounted on a common standing carriage, pointing to the front, to be dismounted and taken across a space of 50 feet, and then mounted on another carriage, the gun to point to the front. Stool bed and coin replaced.

The gun is not to be thrown on to the long skid, carriage not to be taken off the platform or similar space."



A list of stores allowed is then given.

"The detachment to consist of one Officer or N.-C. officer as a Commander and 19 N.-C. officers or gunners.

The detachment performing the shift in the shortest time to be declared the winner.

Prize—Twenty dollars—Badge, and Handbook Field Service, to No. 1.

By order,
J. B. DONALDSON, Lieut.,
Secretary and Treasurer."

Kingston, Ontario,
April 4th, 1882.

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exercises, and under Major Kensington, R.A., and Captain Fairtlough, R.A., have indeed made wonderful progress. In 1881, and again this present year,[1] two Cadets each time accompanied the Canadian team to compete at Shoeburyness with the Artillery Volunteers of Great Britain. The members of the winning detachment, at competitive exercises, wear distinguishing badges on their arms, and skill in swordsmanship, &c., is similarly honoured.

A visit was then made to the class rooms in which the Cadets were going through their studies; in one room was Lieut.-Colonel Oliver, R.A., who, in addition to other subjects, instructs the Cadets in Practical Astronomy, the usefulness of which was shewn in finding bearings, and keeping in the right direction during night marches in the late Egyptian War.

With regard to interior economy and general arrangements, it may at first sight seem strange that many enter this institution to learn military subjects, as on leaving it, the great majority of the Cadets take to civil life, though they become Officers of the Militia; but it is decidedly popular among the young men of Canada, who like the military and manly tone of the College, where games and athletic sports are practised with great vigour and success. Thanks to the liberality of the Canadian Government a good education can be obtained at a very moderate cost, not only in military subjects, but also in Civil Engineering, Architecture, or Land Surveying, if desired, and thus a young man has a good opportunity of beginning to learn a profession, for which there will probably be a continued demand in a rising and rapidly developing country like Canada.

An entrance examination, which may be either in English or French, is imposed; this is not competitive, but it is not always passed by all candidates, and some are regularly rejected. The age on admission is from about 15 to 18 years. The Cadets are enlisted, and each has a set of arms and accoutrements entrusted to his charge, which he has to keep clean and in good order: they show kit like soldiers, and

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The following reports were received :—

"Kingston, Ontario, November, 1882,

Secretary, D. A. A.

Sir.—On the 31st ultimo, I acted as umpire for the Gentlemen Cadets, Royal Military College, in the Shifting Ordnance Competition as detailed in Circular No. 11.

The operation was excellently well performed in 1 min. 15 sec.

Lt.-Col. Campbell acted as time-keeper.

I have the honor to be, Sir,
Your Obedient Servant,
(Signed) C. E. MONTIZAMBERT, Lt.-Col."

"The time of the competing detachments was as follows:

Cadets, R. M. C....	1	min.	15 sec.
No. 1 Battery, P. E. I. Brigade	2	"	35 "
No. 5 Battery, Montreal Brigade	3	"	23 "

The Gentlemen Cadets are therefore entitled to the special prize as in previous years."

[1] No Canadian team came over in 1882, but if it had, it was intended that two Cadets should formed a part of it.

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mount guard in turn, twice a week, on half-holidays. Great efforts are made to acquaint them with the details of a soldier's life, and the discipline is evidently good: the idea being that the military education should be so complete, that if, after years of civil life, a graduate of this College should have to take to military pursuits, he may still be possessed of military habits.

The Cadets numbered 68 last January (there is no room for more in the present building), and they doubtless have considerable *esprit de Corps*, as one may judge from the remarks of a young Royal Artillery Officer from the Canadian College, when being shewn round the R. M. Academy, Woolwich, some eighteen months ago—"The gymnasium, workshops, &c., are very good" he said; "our Canadian College has not so much, but we have only been in existence for five or six years, while you have had more than a hundred; give us time, and see what we shall become."

The Cadets have many friends in the neighbouring town of Kingston, thus they contrast with those at West Point; at both Colleges a voluntary Bible Class is held weekly, and at each the attendance is considerable.

A scarlet uniform with blue facings and gold ornaments is worn throughout the year, a fur cap and mits in winter taking the place of a white helmet and gloves in summer: the Staff-Sergeant Cadets wear a special great coat trimmed with astracan, the same as on the cap. During the hottest months of the year, July and August, the College is closed for the vacation, and thus no specially cool summer uniform is required.

With regard to the Staff, it is at present composed almost entirely of Officers of our army, who each receive a step of local rank. It is intended that Canadians shall eventually take up some, at least, of the appointments; already two Officers of the Canadian Militia, Lieuts. Würtele and Cochrane (graduates of the College), are doing duty as subalterns under two professors as Captains of Companies; they also assist in instructing in various subjects. Owing to the peculiar requirements of this College at the beginning of its career, it is very evident that considerable work has been imposed on each member of its necessarily small staff, as not only has each Officer to undertake several distinct duties, but in every branch text books[1] have been written and published

[1] The following is a list of these works, written to supplement others, which are also used:—

MATHEMATICS—Arithmetic and Conic Sections. Printed notes on each. By Major E. Kensington, R.A.

Statical Problems solved by construction. (Crofton and Kensington).

FORTIFICATION—Guide to Course of Mil. Engineering at R. M. C., Canada. By Capt. G. R. Walker, R.E., and Lieut. H. R. Sankey, R.E.

Explosives for Mil. Engineering, and Electrical Measurements. By Lieut. H. R. Sankey, R.E.

ARTILLERY—Notes on Artillery and S.B. Ordnance. By Capt. S. G. Fairtlough, R.A.

MILITARY LAW—Text Book. By Capt. Douglas Jones, R.A.

MILITARY ADMINISTRATION—Text Book. By Capt. Douglas Jones, R.A.

MILITARY HISTORY, &c.—Tactical Notes. By Capt. Douglas Jones, R.A.

PRACTICAL ASTRONOMY with the Elements of Geodesy. By Lt.-Col. J. R. Oliver, R.A.

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by the professors and instructors. Civilians teach French, Freehand Drawing, Civil Engineering, and Natural Sciences.

A public day is held each year, when the Minister of Militia and the General Officer Commanding distribute the prizes, and on one occasion the Members of the Legislation attended.

The College owes its existence to the Canadian Government; but its usefulness would be greatly increased if more appointments could be offered in State Engineering Works, &c., to those who pass through with credit; as this would supply an incentive to work, and more young men would be induced to apply for entrance. This Institution has long since passed through the experimental stage, having been in working order since June, 1876, when it was opened, and it is now fairly established—already a new wing is spoken of; and there seems every reasonable probability of its continued and extended usefulness.

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ABSTRACT OF THE PROCEEDINGS

OF THE

FORTY-SIXTH ANNUAL GENERAL MEETING

OF THE

ROYAL ARTILLERY INSTITUTION.

THE 46th Annual General Meeting was held in the Theatre of the Institution on Thursday, 17th May, 1883, Maj.-Gen. H. A. Smyth, Comdg. the Woolwich District, in the Chair.

I. The Notice convening the Meeting was taken as read.

II. The Abstract of the last Annual General Meeting was taken as read.

III. The Forty-sixth Annual Report, which was as follows, was read:—

1. The Committee beg to submit the 46th Annual Report of the Royal Artillery Institution.

2. There are now 1583 Members of the Institution, against 1586 last year. 98 Officers joined during the year, against 79 last year; while the deaths and withdrawals amounted to 102.

The number of deaths was 17, against 15 last year. Among them are to be noted those of two distinguished Officers of the late Bengal Artillery, Sir G. Brooke, K.C.B., and General G. Campbell, C.B.; Lt.-Gen. S. E. Gordon, C.B., the founder of the "List of Service Ordnance," to whom the Geological Museum of the Institution owes much of its present completeness; Major-Gen. J. E. Michell, C.B., the author of the "Records of the Horse Brigade;" Colonel O. H. Goodenough, whose useful "Manual of Interior Economy" was for a long time the only book of the kind; and Major A. D. Burnaby, Secretary of the Institution from December, 1868, until October, 1871.

3. The accounts have been audited this year by Lt.-Col. Wethered, and Major Feilden, Staff Paymaster, R.A.

Appendix B shows that the financial condition of the Institution is very satisfactory.

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APPENDIX A.

INCREASE AND DECREASE OF MEMBERS OF THE R.A. INSTITUTION

During the year ending 31 March, 1883.

Ranks.	31st March, 1883.	Increase.			Total increase.	Decrease.				Total decrease.	31st March, 1883.
		Promotions.	Retirement.	New Members.		Promotions.	Retirement.	Withdrawal.	Death.		
EFFECTIVE LIST.											
Generals and Regimental Field Officers	539	55	—	—	55	—	15	41	7	63	531
Captains	385	49	—	—	49	55	5	12	1	73	361
Lieutenants	448	—	—	97	97	49	—	14	3	66	479
Paymasters	3	—	—	—	—	—	1	—	—	1	2
Riding-Masters	3	—	—	—	—	—	—	—	—	—	3
Quarter-Masters	1	—	—	—	—	—	—	—	—	—	1
Medical Officers	3	—	—	—	—	—	—	—	—	—	3
Veterinary Surgeons	3	—	—	—	—	—	—	—	—	—	3
RETIRED LIST.											
Generals and Regimental Field Officers	97	—	15	—	15	—	—	14	5	19	93
Captains	44	—	5	—	5	—	—	2	1	3	46
Lieutenants	13	—	—	—	—	—	—	2	—	2	11
Paymasters	—	—	1	—	1	—	—	—	—	—	1
Medical Officers	1	—	1	—	1	—	—	—	—	—	2
Chaplains	1	—	—	—	—	—	—	—	—	—	1
Honorary Members	45	—	—	1	1	—	—	—	—	—	46
Totals ...	1586	104	22	98	224	104	21	85	17	227	1583

APPENDIX B.

GENERAL ABSTRACT

OF THE

ACCOUNTS OF THE ROYAL ARTILLERY INSTITUTION,

From 1 April, 1882, to 31 March, 1883.

CASH ACCOUNT.

Payments.	£ s. d.	£ s. d.
A—Printing { Wages	115 10 4	
Materials and Printing	404 14 2	
Woodcuts	6 6 6	
Lithography	122 12 9	649 3 9
Photography		31 14 7
B—Classes		248 19 2
Lectures		17 12 11
Washing and Cleaning		27 11 2
C—Library, and Books for Sale		329 15 1
Museum		37 3 0
Observatory and Repairs to Telescope		75 6 10
D—Carpentry { Wages	18 5 2	
Materials	43 16 1	62 1 3
Furniture and Repairs		20 3 4
Subscriptions to Societies		3 3 0
E—Stationery		167 6 9
F—Postage and Parcels		115 8 9
Incidental Expenses		19 8 6
Wages to Clerks and Orderlies		142 8 5
G—W.O. Photographs and Lithographs		1 16 10
Gold and Silver Prize Medals		13 6 0
Fire Insurance		13 18 6
Cash in hand, 31 March, 1883 { Of Secretary	0 16 8	
" Messrs. Cox & Co....	521 17 1	
" London & County Bk.	113 19 5	
" Army & Navy Co-op. Soc.	25 2 1	661 15 3
		£2638 3 1

Receipts.	£ s. d.	£ s. d.
Cash in hand, 31 March, 1883		545 19 6
A—Printing		28 10 9
Photography		2 2 6
B—Classes		58 5 6
C—Books and Binding		304 16 2
D—Carpentry		12 13 0
Subscriptions: Arrears, paid in 1882-3 for { Entrance...		97 0 0
Annual..... 1882-3		1275 18 0
Entrance	1 0 0	
1875-6	0 16 0	
1876-7	1 16 0	
1877-8	1 16 0	
1878-9	2 0 0	
1879-80	3 16 0	
1880-1	7 6 0	
1881-2	18 15 0	
In advance... 1883-4	8 7 0	1418 10 0
E—Stationery sold		141 8 3
F—Postage and Parcels		57 3 11
G—W.O. Photographs and Lithographs		1 10 10
Dividends on Consols		67 2 8
		£2638 3 1

CAPITAL ACCOUNT.

Dr. Liabilities	£ s. d.
Printing Materials, Woodcuts, and Lithography	111 18 8
Classes	14 14 0
Museum	7 10 0
Books and Periodicals	161 8 6
Carpentry Materials and Picture Framing	2 10 5
Postage and Parcels	2 16 0
General Credit 31 March, 1883	2963 6 10
	£3264 4 5

Assets.	£ s. d.	£ s. d.	Cr. £ s. d.
Cash in hand, 31 March, 1883			661 15 3
£2300 Consols Stock, at 98½			2284 13 4
Value of Stock: { Printing Paper	38 16 2		
Books for Sale	20 12 1		
Stationery for Sale	4 17 7		84 5 10
Chemicals in Laboratory	20 0 0		
Owing by Members: { Printing	1 1 11		
Classes	5 8 6		
Books	66 2 3		
Carpentry	9 16 7		233 10 0
Subscriptions	62 17 0		
Stationery	57 18 0		
Postage and Parcels	20 19 9		
W.O. Photos. & Lithos.	0 6 0		
		£3264 4 5	

Examined and found correct,
E. R. WETHERED, Lieut.-Colonel.
H. W. FEILDEN, Major, and Staff Paymaster, R.A.
WOOLWICH, 3 May, 1883.

H. W. L. HIME,
Major,
Secretary, R. A. I.

APPENDIX C.

TABULAR ANALYSIS OF THE STATE OF THE R.A. INSTITUTION

From 1838 to 1883.

I. Year.	II. Number of Members	III. Income.	IV. Expenditure.	V. Amount in the Funds.	VI. Liabilities.	VII. Cash Balance.	VIII. Percentage of Members on Active List to total strength of Regiment.
		£	£	£	£	£	
1838-9	325	510*	272	—	—	343	—
1839-40	351	105					—
1841-2	384	155	119	—	—	194	—
1842-3	447	210	171	120	—	117	—
1843-4	459	156	143	150	—	101	—
1847-8	?	194	111	300	—	116	—
1850-1	587	296	165	500	—	203	—
1851-2	—	173	104	500	—	—	—
1852-3	—	214	136	500	—	—	—
1853-4	—	918†	978	500	—	—	—
1854-5	—	510	742	500	—	—	—
1855-6	714	580	368	500	—	212	96
1856-7	746	665	695	500	—	182	82
1857-8	?	588	647	1200	—	123	—
1858-9	794	640	709	1200	—	54	83
1859-60	863	690	733	1200	—	2	80
1860-1	986	740	733	700	—	9	82
1861-2	1037	800	807	700	—	2	84
1862-3	1108	936	838	1200	—	100	55‡
1863-4	1167	977	1051	1200	249	26	59
1864-5	1213	987	996	1200	240	17	58
1865-6	1263	1030	1028	1200	301	19	60
1866-7	1315	1075	1088	1200	482	6	63
1867-8	1336	1097	1040	1200	316	61	65
1868-9	1377	1115	1167	1200	99	9	66
1869-70	1366	1122	1011	1361	73	120	66
1870-1	1380	1156	1273	1686	185	3	67
1871-2	1377	1174	1153	1686	91	24	65
1872-3	1385	1190	1118	1686	425	96	68
1873-4	1441	1247	908	1686	232	433	76‖
1874-5	1485	1313	1475	2000	111	271	78
1875-6	1498	1320	1079	2000	385	512	78
1876-7	1530	1328	1496	2000	100	344	80
1877-8	1553	1338	1439	2000	145	243	82
1878-9	1555	1367	1198	2000	105	412	83
1879-80	1565	1389	1169	2000	91	632	83
1880-1	1558	1396	1632	2300	162	395	81
1881-2	1586	1465	1314	2300	229	546	85§
1882-3	1583	1485	1369	2300	301	662	85

* Includes £200 Donations.
† About £700 of this year's income was subscribed for furnishing new building.
‡ The Indian Artilleries amalgamated in this year.
‖ Medical Officers removed in this year from the strength of Regiment.
§ Veterinary Surgeons removed from the strength of the Regiment.

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The cash which passed through the Secretary's hands amounted to £2638 3s. 1d., against £2450 18s. 11d. last year; which is some evidence of the increased work done by the Institution.

The General Credit, shown in the Capital Account, is £2963 6s. 10d. against £3072 19s. 4d. The decrease is apparent, not real; being due to certain bad debts having been struck off in the course of the year. The printing account has risen, and the receipts have fallen in comparison with last year. The reason is, that while there has been an increased demand for printing on the one hand, on the other many valuable papers and tables, including Capt. Jocelyn's excellent "Précis of Tactics," have been published and issued *gratis* for the use of Members.

The Photography has risen from 13s. 7d. last year to £31 14s. 7d. this year. The increase is due to the Studio having been put in thorough repair, at a cost of £28, and a class started.

The expenditure on Classes has increased £100, the Committee cheerfully responding to the increased demand for assistance. The income, it will be observed, has also increased under this heading.

The charge for the Equatorial Telescope is also much higher than last year, the Committee having considered it desirable to have the Instrument put in complete repair before the late Transit of Venus. Owing to the state of the atmosphere, no observation was taken either in Woolwich or Greenwich.

In consequence of the discovery of an old and forgotten Book of Records in the re-arrangement of the Library, the Committee have been enabled to trace back the financial history of the Institution to its first beginning, 1838. These interesting details are given in Appendix C.

4. The Landscape Drawing Class has retained its popularity. Classes and individual Officers have been assisted by Institution funds at several out-stations for the study of Spanish, Italian, Russian, Turkish, and Landscape Drawing.

5. The Committee have continued the supply of Foreign Military Periodicals to Members willing to furnish from time to time, for publication with the "Proceedings," Reviews and Précis of their contents, as well as Translations in full of important articles.

6. The subject selected for the Prize Essay of the year was "The duties of the *Personnel* of a Battery of Field Artillery in action, from the time it takes up a given position until 'Cease Firing' is sounded." Seven Essays were submitted for competition.

Colonel Fox-Strangways, Colonel Stirling, C.B., and Colonel Harness, C.B., were good enough to act as Judges.

In accordance with the recommendation of the Judges, the Committee

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decided to adjudge a silver medal to the author of Essay, Institution No. 2, provided that this Essay does not exceed the prescribed limit of 16 pages.

7. Colonel Goodenough, C.B., Colonel Fox-Strangways, and Major Clayton consented to act as judges for the rewards, offered to the five best papers in the "Proceedings" in the Circular of the 21st December, 1882. The Committee adopted their recommendations—five rewards of £5 to the writers of the following papers (given in alphabetical order):—

"Railways in War," . .	Grierson, Lieut. J. M.
"History of Gas-checks," .	Hawkins, Captain G. W.
"Simple Farriery," . .	Hotham, Captain J.
"Siege of Potchefstroom," .	Rundle, Lieut. H. M. L.
"Strategical Geography," .	Walford, Captain N. L.

8. The first volume of the late Lieut.-Colonel Cleaveland's Notes upon the History of the Regiment, embracing the period from 1716 to 1763, is in course of publication.

9. The Committee purchased during the year one of General Hannyngton's Slide Rulers, the use of which, they hope, will form the subject of a paper in the "Proceedings."

10. During the year the Library has been thoroughly overhauled and re-catalogued. This has naturally increased the expenditure under the head of printing.

A proposition has been made (and approved of by the R.A. Library Committee) for placing the R. A. and R. A. I. Libraries (the former exclusive of the Lending Library) under one head, the Secretary, R. A. Institution. The matter is so important that the Committee have postponed it for further discussion.

11. The following Lectures were delivered during the year:—

Attitudes of Animals in Motion ... Mr. E. Muybridge.

The Transit of Venus across the Sun on 6 Dec. 1882 ..... } Capt. G. Mackinlay, R.A.

12. The following changes in the Committee took place during the year:—

Lieut. C. A. Ryan	vice	Lieut. F. J. A. Trench.
Major F. E. B. Loraine	"	Major R. C. Drysdale.
Colonel O. H. A. Nicolls.....	"	Colonel H. T. FitzHugh.
Major T. J. C. A. Studdy ...	"	Major J. H. Blackley.
Lieut.-Col. C. Thornhill	"	Major F. E. B. Loraine.
Captain C. Russell	"	Capt. C. A. Ryan.
Lieut. R. Tylden.....	"	Lieut. C. S. B. Parsons.
Major E. H. Cameron.....	"	Major H. S. Clarke.

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The Committee at present (1st April, 1883) is constituted as follows:—

PATRON AND PRESIDENT:

Field-Marshal H.R.H. The DUKE OF CAMBRIDGE.

VICE-PRESIDENTS:

The Inspector-General of Artillery.
The Director of Artillery and Stores.
The Deputy-Adjutant-General, R.A.
The General Officer Commanding Woolwich District.

MEMBERS:

The Assistant-Adjutant-General, R.A.
The Director of Artillery Studies.
The Assistant-Adjutant-General, Woolwich.
The Secretary, Department of Director of Artillery and Stores.
General W. J. Smythe, F.R.S.
General Sir J. H. Lefroy, C.B., K.C.M.G., F.R.S.

Colonel E. Maitland.	Major T. J. C. A. Studdy.
" O. H. A. Nicolls.	" S. C. Pratt.
Lt.-Col. C. E. Nairne, C.B.	Capt. R. S. Watson.
" H. B. Maule.	" J. M. Alves.
" *Hon.* A. Stewart.	" C. Russell.
" C. Thornhill.	" J. R. J. Jocelyn.
Major E. H. Cameron.	Lieut. R. A. Bannatine.

Lieut. R. Tylden.

Major H. W. L. Hime, *Secretary and Treasurer.*

Assistant Secretary.

TRUSTEES:

General Sir J. St. George, K.C.B.
" Sir E. C. Warde, K.C.B.
D.-A.-G., R.A., for the time being.

IV. The Annual Report having been read to the Meeting, it was proposed and carried:—

"That the Annual Report, as read, be adopted."

V. The Secretary was requested to open the sealed envelope containing the name of the author of Essay No. 2, to which a silver medal had been adjudged, provided it did not exceed the prescribed limit of length. On doing so, Lieut.-Colonel W. Kemmis was found to be the successful competitor—this being the third occasion on which Lieut.-Col. Kemmis has carried off a medal.

VI. It was proposed and carried to request the Deputy-Adjutant-General, R.A., to obtain the sanction of H.R.H. Field Marshal the

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Duke of Cambridge, Colonel of the Regiment, that the following be the subject for the Prize Essay for 1884 :—

"The Selection and Training of Officers of the Royal Artillery."

It was also proposed and carried that in case H.R.H.'s sanction cannot be obtained, the following be the subject of the Prize Essay for 1884 (with the usual limitation) :—

"The Machine Gun: has it a position in the Field, in a Siege Train, or in a Fortress?"

VII. Colonel E. Maitland and Major S. C. Pratt, whose term of office on the Committee had expired, were re-elected.

VIII. It was proposed and carried that the following changes take place in the Rules :—

RULE II.—To read as follows :—

"II. Officers of the Royal Engineers, Royal Marine Artillery, and professors and masters of the Royal Military Academy, are eligible to become honorary members. They may obtain the periodical publications of the Institution, on the annual payment, in advance, of the sum of 10s. 6d.

Officers of the Militia Artillery are eligible for the same advantage, and when on duty at Woolwich may be allowed the use of the Institution."

RULE XIX.—To read as follows :—

"XIX. The Institution will bear a share of the expense of a class at any out-station, at which as many as three of its members combine for the purpose; provided that the members in question do not receive pecuniary rewards from other sources. In that case it will be for the Committee to decide whether any assistance, and how much, be afforded."

(Signed) H. A. SMYTH,
Major-General,
Chairman.

17 May, 1883.

APPENDIX D.

Presentations to the Library.

Two original water colour plates illustrative of experiments with Shrapnel Shell, 29th May, 1805, signed by Colonel H. Shrapnel, R.A....	By Order of Her Majesty, "The Queen."
A curious print of a Machine gun invented by Mr. James Puckle.....	

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Sixth Annual Report of H.M. Inspector of Explosives	The Right Hon. the Sec. of State for Home Dept.
Report on the Circumstances attending the Burning and Explosion of a quantity of Fireworks in a Dwelling-House in Hanley, on the 6th March, 1882	
Report on the Circumstances attending an Explosion which occurred on Premises occupied by Mr. William Riley, Albumen Manufacturer, Drysalter, &c., in Henry Street, Castleton, near Manchester, on the 19th April, 1882	
Report on the Circumstances attending an Explosion which occurred in the Factory of Nobel's Explosives Company (Limited), at Ardeer, near Stevenston, in the County of Ayr, on the 8th June, 1882	
Report on the Circumstances attending an Explosion which occurred in the Factory of Nobel's Explosives Company (Limited), at Ardeer, Ayrshire, on the 27th October, 1882	
Report on the Circumstances attending an Explosion of Wet Tonite or Cotton Powder during the operation of Pressing the same into Blasting Cartridges, at the Works of the Cotton Powder Company (Limited), at Uplees Marshes, near Faversham, on the 5th November, 1882	
Report on the Circumstances attending an Explosion which occurred during the manufacture of Fog Signals at Messrs. Dyer and Robson's Ammunition Factory, at Greenwich Marshes, on the 28th November, 1882	
Report on the Circumstances attending an Accident which occurred in the Factory of the Potentite Company (Limited), at Melling, near Liverpool, on the 15th July, 1882.	
Report on the Circumstances attending an Explosion which occurred in the Askham Iron Furnaces, near Barrow-in-Furness, on the 8th December, 1882	
Report on the Circumstances attending an Accident which occurred in the Factory of the Potentite Company (Limited), at Conscough Bridge, near Melling, in Lancashire, on the 26th January, 1883	
Army Act, 1881. Second Edition, 1882	Secretary of State for War.
The Armed Strength of Belgium	
Litho. Plates, R. G. F., Nos. 5046, 5047, and 5048	
Litho. Plates, R. L., 130 to 140	
" " R. C. D., 59a, 90, 100	
W. O. Photographs. Nos. 6014, 6015, 6018, 6022, 6023, and 6024	
4-Sheet Map of Egypt	
The Armed Strength of Russia	

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Report on Egypt	Secretary of State for War.
The Franco-German War, 1870–71. 2nd Part, 17th Section	
Sketch of Formation for Attack, Tel-el-Kebîr	
Sketch of the Field of Operations at Kassasin and the Lines of Tel-el-Kebîr	
Tel-el-Kebîr: Entrenched Position of Egyptian Forces, 13th September, 1882	
Handbook for 7-pr. (200 lb.) Gun on Colonial Carriage, 2 copies	
Depression Range-Finder for Elevated Batteries, 2 copies	
The Armed Strength of Spain, with Map	
Précis of Information concerning the Island of Ceylon, with a Map	
Provisional Handbook for the 13-pr. R.M.L. Gun of 8 cwt.	Director of Artillery.
Range Tables for 11-inch R.M.L. Gun	
" " 12 " " of 25 tons	
" " 10 " "	
" " 12·5 " " of 38 tons	
" " 9-pr. of 6 cwt., 2 copies	
" " 17·2-inch R.M.L. Gun, based on calculation, 28th February, 1882. 2 copies	
Testing and Proving Gunpowder as carried out at the Royal Gunpowder Factory, Waltham Abbey, and the Royal Gun Factory Proof Butts, Woolwich	
Official Catalogue of the Museum of Artillery, 4 copies	
Useful Rules and Tables, by Lieut.-Colonel W. H. Noble, R.A. 2nd edition, 1882	
Handbook for 9-pr. R.M.L. Gun of 6 cwt. (Land Service), 1883	
Handbook for 16-pr. R.M.L. Gun of 12 cwt., 1883	
Plans of Kits (Coloured). 3 sets	D. A. General, R.A.
Military Field Pocket Book (Scharnhorst's)	Captain W. F. de H. Curtis, R.H.A.
Remarques sur la Cavalerie (Warnery's)	
Courts-Martial, by Major C. James (late R.A.)	
Œuvres Militaires, by J. A. H. de Guibert. 2 vols., with Atlas	
Training of Cavalry Remount Horses, by Capt. N. E. Nolan, 15th Hussars	
Synopsis of Practical Perspective, lineal and aerial, by T. H. Feilding	
Thoughts on Tactics and Military Organization, together with an Enquiry into the Power and Position of Russia, by Lieut.-Col. J. Mitchell	
Instructions for the Field Service of Cavalry, by Capt. L. Beamish, 4th Dragoon Guards	
Duties of Troops Composing the Advanced Corps of an Army, by Lieut.-Colonel Leach, C.B., (late Rifle Bde.)	
The Barrack Ready Reckoner, by T. Smith, Esq.	

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The Subaltern's Check Book, by Bt.-Major Sir Phelim O'Doodle, Kt., (late of the 75th Royal Romney Marsh Fencibles)	Captain W. F. de H. Curtis, R.H.A.
Histoire des exploits et des Vicissitudes de la Cavalrie Prussienne dans les Campagnes de Frederic II. Traduite de l'Allemand, Par le Baron de Canitz	
The Details of the Rocket System, by Colonel W. Congreve, R.A.	
Die Elementar-Taktik der Preussischen Armee nach den Exercier-Reglemento der drei Waffengattungen dargestellt: mit Erläuterungen. Berlin, 1838, by Eugen von Hartwig.	
Handbook for Field Service, 1857	
" " " 1862	
The Military Discipline, wherein is martially shewne the Order for Drilling the Musket and Pike, 1 vol. London, 1642	Captain W. Whateley, R.A.
Military Instruction for the Cavalrie. 1 vol. Cambridge, 1644	
Report and Appendix on the Mutinies in the East Indies	General H. L. Gardiner, R.A.
Report on the conduct of certain Officers on the General Staff, and others in the Army	
Report on the Purchase and Sale of Commissions in the Army	
Report and Appendix of the Commissioners for training Officers for the Scientific Corps	
Manual para uso dos Officiaes inferiores de Artilheria	The Portuguese Artillery Improvement Committee.
Relatorio dos trabalhos da commissao de aperfeiçoamento da arma de Artilheria no Annos. 1871 – 81, Lisboa, 1879 – 82	
Direccao geral da Artilheria, 24 de Janeiro de 1882	
Instruccoes elementares provisorias para a execuçcao da pontario e do tiro nas peças de campanna, Lisboa, 1881.....	
Programma para os exercicios da Escola Practica de Artilheria no polygons das vendas novas no anno de 1882, Lisboa, 1882.....	
Pequeno Manual para uso do soldado Artilheiro Lisboa, 1881.....	
Ducalion: collected studies of the lapse of waves and life of stones	J. Ruskin, LL.D.
The Works of John Ruskin { Vol. X. The Two Paths ..... Vol. XI. A Joy for ever	
Love's Meinie. Lectures on Greek and English Birds	
Tactical Notes: compiled for the use of the Gentlemen Cadets of the Royal Military College of Canada, by Major Douglas Jones, R.A.	The Author.
Text-Book of Military Law: for the use of the Gentlemen Cadets of the Royal Military College of Canada, by Major Douglas Jones, R.A.	

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Report of the Examination for Admission to the Staff College, held in June, 1882.	Dir.-Gen. of Military Education.
Report of the final Examination at the Staff College, held in December, 1882, with copies of the Examination Papers	
Sketch Map of Lower Egypt	R. E. Institute.
Map of the Port of Alexandria	
" Suez Canal	
Professional Papers of the Corps of Royal Engineers. Vol. 7	
The Royal Engineer Journal (monthly)	
Ordnance Notes, Washington, United States	General S. V. Benet, Chief of Ordnance, United States.
Report of the Chief of Ordnance, Washington, United States, 1881	
Report of the Astronomer Royal to the Board of Visitors, Greenwich, 3rd June, 1882.	The Astronomer Royal.
Greenwich Magnetical and Meteorological Results, 1880.	
Official Army Register for January, 1882.	U. S. Military Academy.
Analytical Digest of the Military Laws of the United States, by R. N. Scott	
The Militia List of the Dominion of Canada, corrected to January, 1883	The Inspr.-General of Artillery, Kingston, Canada.
Report of the State of the Militia of the Dominion of Canada, 1882	
Proceedings of the Scientific Meetings of the Zoological Society of London for the Year 1882	The Council.
Index of Proceedings from 1871 – 1880	
Journal of the Royal United Service Institution	The Council.
Proceedings of the 51st Anniversary Meeting, 1882	
Smithsonian Report, 1880	The Council, Smithsonian Inst.
Publication of the Bureau of Ethnology, Vol. I.	
List of Foreign Correspondents, corrected to January, 1882	
Sketch of country between Alexandria and Kafr Dwâr	The Assist. Qr.-Mr.-General.
Journal of the Iron and Steel Institute	The Council.
Journal of the Military Service Institution of the United States. Vol. 3, and No. 13, Vol. 4...	The Council.
Journal of the United Service Institution of India, Nos. 51 – 54	The Council.
Proceedings of the United States Naval Institute, Nos. 3 and 4, Vol. 8, and No. 1, Vol. 9	The Council.
Proceedings of the Institution of Mechanical Engineers, to date	The Council.
Minutes of Proceedings of the Institution of Civil Engineers, 1882–83, Part 1.	The Council.
The Archæological Journal, Vol. 39, and No. 157, Vol. 40	The Council.
Examination Papers, Royal Military Academy, Woolwich, July, 81	Governor, R. M. Academy.
Examination Papers, Royal Military Academy, Woolwich, Feb. 83.	

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Relazioni Arsenale Militar Marittima Di Spezia, with Plates 1–25	The Committee of Artillery and Engineers, Rome.
Plates of the Netherlands Artillery Atlas, Nos. 48, 50, 125, 127, 128, 131, 133 and 136	The Netherlands Legation.
Revista Militar Española	Spanish Government.
Russian Artillery Journal, to date	Russian Government.
" Small Arms Journal, to date	
Revista Marittima, to date	Italian Government.
Ratnik, to date	Servian Government.
Memoir of Major Henry Bowyer-Lane, of the Royal Artillery, by his son, Major F. W. Bowyer-Lane, late of the 67th Regiment, and Staff of the Auxiliary Forces	The Author.
The Quarterly Journal of Veterinary Science in India, and Army Animal Management, by Charles Steel, F.R.C.V.S., I.V.S.	The Author.
Practical Astronomy and Geodesy, by Lieut.-Col. J. R. Oliver, R.A. 2 copies.	The Author.
Jahrbücher für die Deutsche Armee und Marine, G. von Marées, Berlin, May, 1883	The Author.
The Highlands of India, by Maj.-Gen. D. J. F. Newall, late R.A.	The Author.
Some of the Dangerous Properties of Dust, by F. A. Abel, Esq., C.B., F.R.S.	The Author.
The Defence of the Kingdom, by Major Arthur Parnell	The Author.
Magazine Rifles, by Lt.-Col. G. V. Fosbery, V.C.	The Author.
Army Medical Organization, by Surgeon-Major G. J. H. Evatt, M.D.	The Author.
Text Book of Gunnery, by Capt. G. Mackinlay, R.A., 1883	The Author.
Office Manual, 1882, for Batteries of Royal Horse Artillery and Field Artillery, by Lt.-Col. R. W. Phipps, R.A.	The Author.
Map of Central Asia (in relief)	Gen. Sir J. M. Adye, G.C.B., R.A.
Gibraltar and Ceuta, by General Sir Wm. Codrington, G.C.B.	The Author.
Army List for the Year 1777	Gen. A. T. Phillpotts, R.A.
Rules for the erection of Lightning Conductors	Col. V. D. Majendie, late R.A.
Army List for the Year 1807	Capt. R. H. Murdoch, R.A.
Map of the Country around Sydney, N.S.Wales.	Col. C. F. Roberts, late R.A.
Report of the Royal Commission on the Military Defences of N. S. Wales	
Progress Report of the Committee on Saddlery, 25th January, 1882	Capt. A. H. C. Phillpotts, R.A.

APPENDIX E.

Books, &c., Purchased.

Defence and Attack of Positions and Localities. By Colonel H. Schaw.
Practical Hints to Courts-Martial. By J. C. O'Dowd.
Military Transport. By Lieut.-Colonel G. A. Furse.

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Etat Militaire du Corps de l'Artillerie de France. Paris, 1882.
Guerre Franco-Allemande. Par Captain Felix Bonnet.
Jahresberichte über die Veränderungen und Fortschritte im Militarwesen. Berlin, 1882.
The Army and Navy Calendar. 1882–3.
Stieler's. Hand Atlas. Plates 30–2.
Das Schiessen der Feld-Artillerie. Rohne: Berlin, 1881.
The Attitudes of Animals in Motion. By E. Muybridge.
The Ibis. A Quarterly Journal of Ornithology.
Biologia Centrali Americana:—
Zoology. Parts 17–22.
Botany. Parts 13–15.
The Encyclopædia Britannica. 9th Edition. Vols. 14, 15.
Gould's Birds of New Guinea. Part 13.
American Inventions in Small Arms. By C. B. Norton.
A Monograph of the Jacamars and Puff Birds. Part 7.
Salmon's Conic Sections. 6th Edition. 1879.
A Monograph of the Bucerotidæ or Family of the Hornbills. By D. G. Elliot. Part 10.
La Guerre D'Orient en 1877–8. Parts 8 and 9. Paris, 1882.
Egypt; Descriptive, Historical, and Picturesque. Translated by Clara Bell.
Horses and Stables. By Maj.-Gen. Sir F. Fitzwygram, Bart. 2nd Edition. 1881.
A New French and English Dictionary. By E. C. Clifton and A. Grimaux. Paris, 1881. 2 Vols.
L'Art de la Guerre. Paris, 1881. 2 Vols.
Gould's Humming Birds. Part 3.
Electric Light Arithmetic. By R. E. Day, M.A.
Die Kriegerischen Ereignisse in Œgypten Während des Sommers, 1882.
Conic Sections. By C. Smith, M.A.
The Dress, Horses, and Equipment of Infantry and Staff Officers. By Captain H. Hallam Parr, C.M.G.
The Naval Brigade in South Africa, 1877–79. By Fleet Surgeon H. F. Norbury, C.B., R.N.
La Guerre D'Italie, 1859. Par Alfred Duquet. Paris, 1883.
Traite de Tactique. Par H. Bernard. 4 Vols. Tarbes, 1878, '79, '81, and '82.
La Tactique des Trois Armes. Par G. Mazel.
Aide-Mémoire du Partisan Franc-tireur. Paris, 1875.
Une Mission Militaire en Prusse, en 1876. Paris, 1881.
Priced Vocabulary of Stores. 1882.
Histoire Militaire Contemporaine. Paris, 1882.
Gould's Birds of Asia. Part 34.
Aide Memoire Portatif de Campagne à l'usage des Officiers d'Artillerie. Paris, 1864. 2 Copies.
Le Tir de l'Artillerie de Campagne. Par le Major H. Rohne. Bruges, 1882.
L'Artillerie a Cheval et la Cavalrie. Par le Major Schlieben. Anvers, 1875.
Text-Book of Military Topography. 1883.
Réglement sur L'Instruction du Tir. Paris, 1883.
Archiv für die Artillerie und Ingenieur-Officiere. Berlin, 1882.
Neue Militarische Blätter. Berlin, 1882.
Histoire de la Guerre du Pacifique, 1879–80. 2 Vols.
L'Art de la Guerre à l'exposition d'électricité de Paris en 1881.
Beispiele und Erlauterungen. Par Von H. Rohne.

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APPENDIX F.

Presentations to the Museum.

A Collection of Butterflies from Natal	Lt.-Col. C. E. S. Scott, R.H.A.
" Reptiles "	
Six Prints of Royal Horse Artillery and Field Artillery	Maj.-Gen. J. B. Dennis, late R.A.
The Bible of the Orderly-Room of the old 8th Battalion afterwards 8th Brigade, R.A.	Major S. Gardiner, R.A.
A Collection of Birds Skins from Malacca and West Indies (9 in number)	Colonel O. H. A. Nicolls, R.A.
Egyptian Gunner's Quadrant	Capt. N. L. Walford, R.A.
" Wood Time Fuze	
" Percussion Fuze	
" Lanyard	
" Pricker	
" Revolver Cartridges (2)	
" Friction Tube	
Plug of English Shell from Alexandria	
English Time Fuze and Shrapnel Balls (fired)	
Specimen of Stone of which the Forts at Alexandria were constructed	
Bow and 3 Arrows from British Guiana	H. Whitely, Esq., Junr.
Specimen of Woodpecker	Lieut. F. F. Minchin, R.A.
Zulu Beer Basket	Lt.-Col. J. F. Owen, R.A.
Egyptian Friction Tubes	Major H. F. Smyth, R.A.
" Range Tables (2)	
" Fuze	
Remington Rifle from Tel-el-Kebîr	Lt.-Col. L. F. Perry, R.A.
A Combined Turn-screw and Spanner from Tel-el-Kebîr	
A Collection of Birds Eggs from Ceylon (26 in number)	Major W. V. Legge, R.A.
Edible Nest of Nose Swiftlet from the Mountains of Ceylon	
Specimen of Crab Plover from Ceylon	

APPENDIX G.

List of Papers published in the "Proceedings" during the Year.

Practical Astronomy for Explorers. By Major J. R. Oliver, R.A., (Bt.-Lt.-Col.) Professor of Surveying and Practical Astronomy at the Royal Military College of Canada.

Note on Bashforth's Method of Working Trajectories. By Captain P. A. MacMahon, R.A.

Strategical Geography. A Review. By Captain N. L. Walford, R.A.

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Two-inch Combined Time and Concussion Metal Fuze. By Major G. B. Macdonell, R.A.

Recent Experiments with an 11-inch Compound Armour Plate at Shoeburyness. By Major D. D. T. O'Callaghan, R.A.

Railways in War. A Review. By Lieut. J. M. Grierson, R.A.

Advances in Naval Ordnance from 1855 to 1880. A Review. By Captain T. J. Roch, R.A.

The Training of Garrison Artillery for the Attack and Defence of Fortresses. The Gold Medal Prize Essay, 1882. By Colonel H. A. Smyth, R.A.

The Training of Garrison Artillery for the Attack and Defence of Fortresses. The Silver Medal Prize Essay, 1882. By Lieut.-Col. F. G. Baylay, R.A.

Notes on the Equipment of Horse Artillery for Service in Afghanistan, &c., &c. By Lieut.-Col. G. R. Manderson, C.B., R.H.A.

Railways in War. Part II. A Review. By Lieut. J. M. Grierson, R.A.

A Report on Prism Range-Finders. By Lieut. A. H. Russell, U.S.A.

Approximate Quadrature of the Circle. By Capt. J. C. Dalton, R.A.

On Fixing Positions by the more Simple Astronomical Observations, for the use of R.A. Officers engaged in Exploration. By Major E. S. Gordon, R.A.

Notes on the History of Gas-checks. By Major G. W. Hawkins, R.A.

A Tour of the Franco-German Battle Fields. By Lieut. F. G. Stone, R.A.

Journal of the March of a Heavy Field Battery from Fortress Gwalior to Candahar. By Lieut. L. C. M. Blacker, R.A.

Simple Farriery in the Absence of Professional Assistance: with a Table of Weights and Measures. By Captain J. Hotham, R.A.

Norman Ramsay's Exploit. By the Secretary.

Practical Astronomy for Explorers. By Lieut.-Col. J. R. Oliver, R.A.

Memorandums of Artillery Arrangements and Alterations made in Harness, Carriages, Ammunition, &c., on the Expedition to Egypt, 1801. By Brigadier-General Lawson, Commanding the Royal Artillery.

Note on Percussion Fuze used by Egyptians with Krupp Guns. By Captain E. F. Becher, R.A.

The Lines of Kafr Dwar. By Lieut. G. H. McLaughlin, R.A.

The Assault on the Redan. By General S. E. Gordon, C.B.

On the Motion of a Projectile. By Captain P. A. MacMahon, R.A.

Notes on the Embarkation and Debarkation of Horses, and their Care on Board Ship. By Lieut. H. Heywood Clark, R.A.

A Time Fuze for Field Artillery. By Lieut.-Colonel J. B. Richardson, R.A.

The Practice Regulations of some European Artilleries. By Captain R. A. Montgomery, R.A.

Notes on Practice in Cork Harbour. By Captain R. A. Montgomery, R.A.

Hints to Officers taking over Drafts for India for the first time, and conveying them up Country to their Destination. By Captain J. C. Dalton, R.A.

Notes on Field Artillery. (The substance of Lectures delivered at the Royal Military Academy). By Captain S. C. Pratt, R.A.

On the Motion of a Projectile in a Medium Resisting as the Cube of the Velocity. By Captain P. A. MacMahon, R.A.

The Effects of the Increased Powers of Infantry Weapons. By Captain R. F. Johnson, R.A.

Note on "Norman Ramsay's Exploit." By Captain K. Stephenson, R.A.

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APPENDIX H.

List of Précis and Translations published during the year.

FRANCE...
- "Instruction sur la manière d'employer l'appareil à lunette pour la Formation des Pointeurs, by Colonel de Cossigny." By Captain E. Walsh, R.A.
- "Revue Militaire de l'Etranger." By Captain J. C. Dalton, R.A.
  - General Skobeleff's Instructions to the Artillery of his Army before the Attack and Taking of Geok-Tepe, December 30th, 1880.
- "Revue d'Artillerie." April, 1881. By Capt. T. H. Lloyd, R.A.
  - Fortress Artillery.
  - Employment of Range Tables of Rifled Mortars to determine the elements of the Trajectory.
  - Range Finder.
  - Miscellaneous information.
- "Revue d'Artillerie." May, 1881. By Capt. T. H. Lloyd, R.A.
  - Battery No. 1 of Saint Cloud.
  - Schools for Artillery Practice.
  - Miscellaneous information.
- "Revue Militaire de L'Etranger." October, 1881. By Lieut. A. C. Hansard, R.A.
  - The Re-organization of the German Artillery.
- "Revue d'Artillerie." July, 1881. By Capt. T. H. Lloyd, R.A.
  - Indirect Fire of Field Artillery.
  - Miscellaneous Notes.
- "Revue d'Artillerie." June, 1881, and January and March, 1882. By Major T. H. Lloyd, R.A.
  - Miscellaneous Notes.
  - Tactical Studies for Officers of Garrison Artillery.

GERMANY
- "Organ der Militär-Wissentschaftlichen Vereine." Parts 4 and 5, Vol. XXII. By Lieut. J. M. Grierson, R.A.
  - On the Use of Cavalry.
- "Pamphlet." By Major A. E. Turner, R.A.
  - Responsibility.

ITALY.....
- "L'Italia Militare." January and February, 1881. By Lieut. G. E. Weigall, R.A.
  - Fortifications of Ingolstadt.
  - The Education of the Eyesight.
  - Creation of Fortress Artillery in France.
  - Use of Fire-arms forbidden in Fortresses.
  - New Organization of the Swedish Army.
  - Consumption of Cartridges in War.
  - The Bicycle in the Army.
  - Summary of four of the principal European Armies, and the approximate Force each can put into the Field in First Line.
  - A New Rifle.
- "L'Italia Militare." March, April, May, July, and August, 1882. By Lieut. G. E. Weigall, R.A.
  - Intermediate Position of Belgium between France and Germany.

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ITALY.....
- Transport and Provision for the War in Herzegovina.
- New Shell.
- Autumn Manœuvres in Italy.
- Rapid Cavalry Reconnaissance.
- Short Notes on the New Austrian Siege Train.
- Actual State of the French Fortifications.
- New Steel Bronze Ordnance for Austria.
- Strategic importance of Heligoland to Germany.

RUSSIA...
- "Russian Artillery Journal." By Lieut. J. M. Grierson, R.A.
- The Swedish Field Artillery.

SPAIN.....
- "Memorial de Artillería," August and September, 1881. By Captain J. C. Dalton, R.A.
- Instructions for Nos. 1 of Subdivisions of Field Artillery.
- Projectiles and Fuzes.
- Gunpowder and Explosive Compounds.
- On the Duties of a No. 1 of a Field Battery :—
  - (1.) In Garrison.
  - (2.) Marches.
  - (3.) When his gun is in action.
  - (4.) Battery in a Campaign.
- "Memorial de Artilleria." August, 1881. By Capt. J. C. Dalton, R.A.
- An Artillery Barrack in England.
- "Memorial d'Artilleria." By Captain P. A. MacMahon.
- The Precision of Fire-arms.
- "Memorial d'Artilleria. April and June, 1882. By Capt. J. C. Dalton, R.A.
- The Portuguese Army.
- Experiments in Seville with 9^{cm} Gun of Compressed Bronze.
- New Dutch Field Gun.
- Strength of Dutch Army.

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FOREIGN ARMOUR EXPERIMENTS,

AND

THEIR BEARING ON OUR OWN ARMAMENTS

AND

THE BOMBARDMENT OF THE FORTS OF ALEXANDRIA.

A Lecture delivered at the R.A. Institution, on 13th April, 1883,

(MAJOR-GENERAL H. A. SMYTH, COMMANDING THE DISTRICT, IN THE CHAIR.)

BY

CAPTAIN C. ORDE BROWNE,

LATE ROYAL ARTILLERY.

I BELIEVE that there are features in certain plate experiments carried out on the Continent in 1882 that deserve special attention. I propose to give a very brief account of such experiments, dwelling particularly on the points that appear to be important. A paper confined to this would give abundant food for discussion, and any additional matter may distract our attention; nevertheless, the features of these experiments are of too completely a special character to interest all. I have therefore added to the above some remarks on the Alexandria Bombardment, and the application of the knowledge we have gained in experiment to conditions of war which, I hope, will have the effect of promoting discussion, especially as I shall be then speaking freely of matters of which I have only the information which is in the reach of all. That is to say, I am doing two things. As to the question of the foreign experiments I have special information, and as to the other question I have not. There is a better chance of a discussion if I speak of the things which some of you know better than myself; and as there are some present who have seen the ground at Alexandria, and have seen the effect of it, if they have not seen the bombardment, I hope there may be good chance of a discussion arising.

FOREIGN EXPERIMENTS.

It is important throughout to distinguish between "*soft*" armour, which admits of perforation, and "*hard*" armour, which is destroyed by shattering, but which generally stops a projectile as long as it holds

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together or, indeed, remains even held up in its position. The foreign experiments I now propose to notice are (1) Krupp's Meppen trials; (2) the Italian Spezia plate experiments with the 100-ton gun, at the end of last year; and (3) the trial of compound and steel plates at St. Petersburg, at the end of last year and the commencement of this year.

Krupp's Meppen plate trials took place in March, 1882. They consisted wholly in trials as to the perforation of soft armour either directly or obliquely. I have here written down the details and the rounds fired, and I will try and give you, as shortly as possible, the pith of each result. The gun fired was a 5·9-inch, fired twice at two 7-inch plates of wrought iron with 10 inches of wood in between. That plate is represented on the diagram[1] (Fig. 2, "horizontal view," Fig. 3, "front view," Pl. I.) The shot weighed 109·6 lbs. (49·7 kg.). The first was fired with a charge of 39·68 lbs. (18 kg.), and the second 37·5 lbs. (17 kg.). The second one had a velocity of 1750 feet, its striking energy was 2328 foot-tons, and it had sufficient work to have penetrated 11·65 inches of iron in one thickness, or I suppose about 12 inches of iron in two thicknesses. As a matter of fact, it went through the entire target and passed on up the range 328 yards uninjured. That is to be accounted for by the circumstance that the wood between the plates was much too thick. The plates were good, but if the wood is sufficiently thick to allow the point of the projectile to get clear of the bent and broken edges of the front plate before it meets the hinder one, then you do not get at all the maximum resistance out of the plates. All the experiments at Shoeburyness established the fact that the best thickness was somewhere about 5 inches, which prevents one plate jarring on the other, and does not allow the projectile to get clear of the broken pieces of one plate before it comes to the second one. In that way I understand Colonel Inglis to expect that this shot thus fired might get fairly through these plates. It did more than that, and there is no doubt that Krupp's projectiles are particularly good.

The second experiment was one of oblique fire (*vide* Fig. 6, Pl. I.). The same gun was fired at an angle of 35° on the normal, or 55° with the plate, against a plate 7·9 inches (20^{cm}) thick, with a backing of 9·84 inches of wood, and 0·98 inches of skin. Two rounds were fired with charges of 39·68 lbs. and 37·5 lbs. The latter projectile had a striking velocity of 1750 feet. It had sufficient work to have penetrated 9½ inches at the striking angle, supposing the projectile "bit" properly; but at so oblique an angle it has been found that the projectile has to be more than a match for the plate, generally speaking, to bite, and therefore there is no doubt that the penetration was unusually good.

But, however excellent those results are against soft armour, I do not believe that they possess the same interest as hard armour trials. You may go so far as to say that success in firing through soft armour with long projectiles of small calibre is suicidal to that nature of attack.

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[1] The wood blocks for these Figs. have been kindly lent by the Editor of the *Engineer*, in which paper reports of the trials appeared.

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Because, if you get the extreme measure of success, so that you can get a steel shell to go through wrought-iron and burst in the interior, the effect is so intolerable that anything is preferable from a ship's point of view; and I suppose that as soon as you have arrived at that result you have done away with soft armour altogether, and you must have hard armour, let it shatter as it will. But, of course, on that Naval Officers will speak with more authority.

There were other incidental things in Krupp's trials worthy of notice. For example, I may mention that he tried common shells made of steel, the object being to get a thinner shell with a larger bursting-charge, or, on the other hand, make a shell with a much stronger envelope, so that there should be greater resistance when the shells burst. In some experiments—the *Shannon* trial for one—shells have *broken up* instead of bursting inside the plates at which they were fired, and the result has been but small. Thus there is an advantage in having a strong envelope: or, of course, you may take the advantage out the other way, by having a very much larger charge—how very much larger you may see from the fact of an 8·27-inch shell containing 106 lbs. of powder. You can hardly conceive of a shell 8¼ inches containing 106 lbs. bursting-charge. This, no doubt, is a feature which must receive great attention at some time in this country. There was another special object they were trying to carry out, which was, making the shells act on the graze before rebound. They fired shells at the top of splinter-proofs with the object of making them burst, if possible, the instant they touched; and in the end they concluded that it was impossible to do it, and they have almost given up hope of complete success. It seems that directly the shell commences to rise, a great part of the effect is lost.

The Spezia trials of last November consisted in trials of compound plates that were ordered for the *Italia* from Messrs. Cammell, in competition with other compound plates from Sir John Brown & Co., and steel plates from M. Schneider. The dimensions of all were the same—18·9 inches thick, 10 feet 10 inches long, and 8 feet 7 inches wide (*vide* Figs. 1 & 2, Pl. I., for section). Cammell's plates had steel faces made on Wilson's patent, and Brown's plates on Ellis's patent, the back of each being wrought iron, and the front, for about one-third the thickness, steel. The compound plates had rather harder steel faces, having rather more carbon in the steel than in Schneider's steel plates, which was entirely of steel, containing about 0·45 per cent. of carbon. It was not rolled. It was made from a very large pile 7 feet thick, and then hammered down to 19 inches thickness under a 100-ton hammer. In very thick armour it is very difficult to get the quality preserved through to the centre of a large mass. It is important then to note that that was the way in which these plates were made. Schneider's target was held up with twenty bolts, and the others by six bolts each only. They fired, as they always do at Spezia, precisely similar rounds at each target one after the other, using the 100-ton muzzle-loader. The first round was fired with a charge of 328·5 lbs. and a 2000-lb. shot at a low velocity of about 1222 feet, thus reduced so as to be something under a match for the target. Its stored-up work was 20,710

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foot-tons. It was capable of penetrating about 19·33 inches of iron, that is to say, it was a match for the thickness of the target had the target been iron. Of course, each target being compound metal, it ought to have been equal to about five inches more, that is to about 24½ inches of iron, and the shot was therefore not a match for it in penetration. The first shot being fired at Cammell's plate (*vide* Fig. 4, Pl. II.), the head was buried in it, and those cracks which you see upon the diagram were made, the corner being detached. A similar round was fired at Brown's, only that the effect was a great deal less (*vide* Fig. 6, Pl. II.); and at Schneider's the shot buried itself apparently without the slightest crack anywhere (*vide* Fig. 5, Pl. II.).

The next round was fired at each with a charge of 478·3 lbs., having sufficient work to penetrate the targets; that is to say, the shot had enough work in it to penetrate 24·7 inches of iron. The first round so fired had 1545 feet striking velocity, equivalent, I think, to the perforation of 19 inches of compound armour. The stored-up work was 33,100 foot-tons. The effects produced are shown on the diagram. Cammell's plate was broken up into four or five pieces (*vide* Fig. 14, Pl. I.). The whole plate was brought down, the bolts giving way. If you assembled the pieces, they would have the form represented in that diagram (Fig. 15, Pl. II.). In the same way a shot was fired at Brown's plate and brought down part of the target: one corner remained, hanging by a bolt (*vide* Fig. 12, Pl. I.). The fragments are shown assembled in Fig. 13, Pl. II. The second round at Schneider's produced the effect shown in Fig. 7, Pl. II. Of course, the apparent difference between those results is very great, and it is mainly due to the fact that Schneider's target is held up by bolts, whereas the other targets not being sufficiently bolted fell on the ground, but, nevertheless, I think anyone will admit that Schneider's plate held better. The cracks are peculiar. I do not think they show the same complete fractures as the others, and if you had looked at the section of the iron you would have seen the coarse, crystalline, harsh character in all those plates, while the steel had a fibrous tough look about it. I believe, therefore, apart from the question of the bolts, that the plates stood decidedly better. They then fired a steel projectile, thought to be a Whitworth. It had a striking velocity of 1538 feet and about the same stored-up work as before viz., 34,080 foot-tons—about a match in penetration for the target. A great piece of steel was brought down, the projectile was flattened and bounded back, the top frame round the target was thrown to the front so as to overhang the face (*vide* Figs. 19, Pl. II., and 24, Pl. I.). Part of the plate was driven into the back and part brought down with the shot, which rebounded and lay in front (Figs. 20 & 23, Pl. II). An inspection of those pieces of plate would give you the idea of its being remarkably good metal (*vide* Figs. 21 and 22, Pl. II.). It was afterwards stated that the projectile was not a Whitworth shot, but one of Terre-Noire manufacture, sent in mistake for a Whitworth. You see before you an actual Whitworth projectile and a Terre-Noire projectile fired by the Sub-Committee here. There is a great difference between the two shots. This Whitworth shot was an extraordinary projectile; it

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was fired twice at 12 inches of iron, and that projectile has passed twice clean through 12 inches of iron. Major Hime obtained authority to take it, and we discovered it in the range. It was just going to be sold as old metal: we fished it out from under some old metal and got it up here. Having identified it and exhibited it, the claims of the projectile were questioned by the Committee. But its history can be certainly traced out. It had no sooner established its claims than while at the Royal United Service Institution, it was carried off to Shoeburyness. However, Major Hime rescued it, and there it is. It is a notable projectile. I do not suppose, unless Krupp has one, that there is a shot anywhere that has done so much work; and it appears capable of repeating it. *This* is a Terre-Noire projectile: it is made of steel, and you see how much it is set up. If the projectile set up in that way against wrought iron it would set up a great deal more than that against the magnificent Schneider steel. The Whitworth shot is made for the 100-ton gun, and this shot for the 9-inch. It is a great deal more difficult to make equally good shot for the 100-ton gun than for the 9-inch, and that Spezia projectile is enormously beyond this Terre-Noire in merit. I happened to look at that Spezia one before it was fired. It had a point inserted, just as this Whitworth has; therefore I was not at first at all inclined to believe that it was a Terre-Noire; still, unquestionably, people ought to be the best authorities with regard to their own shot. The Italians, so General Younghusband wrote to me, say that it was a Terre-Noire shot; and, if so, it must be admitted that they have succeeded in making very excellent shot for the 100-ton gun at Terre-Noire; and this is a serious thing for us, for they have made on a vast scale a shot, to all intents and purposes, as good as the Whitworth.

They then fired another round. Of course the plate was getting demoralised, and it is hardly worth looking at the result in Figs. 25 and 26, Pl. I. The projectile was a San Vito cast steel shot, and that projectile broke up in a very different way to the last mentioned. The head appeared good, but the body looked as if it was bad: the difference being accounted for by the head having been tempered in oil.

Now I will go on to the St. Petersburg experiments, which began almost on the same day, and were carried on as a competitive trial between Cammell's compound steel and Schneider's steel plates. In this case, the first round fired was the heaviest. It was fired from an 11-inch breech-loading gun. They were 12-inch plates, 8 feet by 7 feet, and the striking velocity was 1506 feet, the charge being 132 lbs. English; the weight of the shot was 553½ lbs., and work in the shot was 8704 foot-tons, and the power of perforation equal to about 16·3 inches of iron—just about a match for the target. The first round fired at the Schneider plate cracked and broke it, as shown in Fig. 1, Pl. I. The next was fired with 81 lbs. of powder, a striking velocity of 1167 feet and 5228 foot-tons work (Fig. 2, Pl. I.); it struck it with a power of perforation of 12·21 inches of iron; and the third, with the same, broke a quarter of it away (Fig. 3, Pl. I.). That

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again was bolted up with a great many bolts, whereas the Cammell had only four bolts. The first round being fired at the Cammell plate with a charge, &c., corresponding to the first round at the Schneider, the projectile of course broke up, as in the previous rounds. The head remained embedded in the plate, and very slight cracks were made (Fig. 4, Pl. I.). The next round, fired with a charge, &c., as in the second round at the Schneider plate, detached the plate, which fell on its face. When it was picked up surface injuries were found to have been produced. The steel-faced plates are apt to have more or less concentric cracks; and, as far as my experience goes, concentric cracks are not produced on a steel plate, but, on the contrary, all the cracks are radial. Then they mounted the Cammell again and fired at it, with the same reduced charge, with the same sort of effect, until they eventually got four shot planted on it, and got the result shown in Fig. 3*a*, Pl. I., parts of the face being scaled off; but the plate holding together and having had a good deal of work left in it. That was done two or three weeks ago, and they expect to fire again at that plate.

In this case there is no doubt the Cammell compound plate has beaten the steel plate; but in the other case I think there is no doubt that the steel was the better of the two. A serious feature is that at Spezia you have 18 inches, and in this case 12 inches. There is a great deal of difference between an 18-inch plate and a 12-inch plate. The 18-inch plate at Spezia was steel, and this result may have something to say to the way in which it was made with the 100-ton hammer. The compound plates at Spezia, partly owing to a misunderstanding, were very badly held up with only six bolts, and showed to a disadvantage. The question is, how far we ought to take that into account. In America I have been accused of finding un-English excuses[1] for the English plates; but I am going to repeat those excuses, for I think they are correct. There is little doubt that Schneider's plate was specially made for this programme of experiments. The other plate was supposed to be a sample plate, exactly corresponding to those that would go on the *Italia;* Schneider's plate was not a common sample plate, but was one made for the particular object. Fig. 30, Pl. I., shows the plate with the bolts seen through the front, as if the plate was transparent. The bolt holes only go part of the way through. There are three circles in the plate, which corresponded to the three points of impact laid down when the plates were first ordered. I had the actual piece of paper sent to Brown's firm ordering those plates, and on that were marked those three rounds. I think I need not say that those bolts are adjusted to meet those three rounds. That is not a service condition; you cannot expect your enemy to fire at your plates in such a way as to enable you to adjust bolts to meet them. On examining Schneider's plate, it was found to be a little thinner at the edges than 19 inches; and on looking

[1] An Italian official report on these trials points out that the soft backing and structure favoured the stiff steel rather than the more flexible compound plates.

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carefully at it it was apparent, I believe, that in tempering, the plate had slightly curved itself, the result of which was that, of course, it was not originally quite flat. They made it flat behind by planing off the ends that projected, so that they left it with a flat back and slightly convex face (*vide* Fig. 31, Pl. I.). That did not affect it for this experiment, because no shot would be planted very near the edge, and so the fact that the edge was a little thinner would not affect the plate at all; but if there were a continuous set of plates fixed next to one another it would affect the matter; and then comes the question, could Schneider have tempered his plate? The English steelmakers say "No"; they say that every single plate on the *Italia* is curved, and that he could not temper a curved plate in oil; and, therefore, if that steel plate was fairly to represent a supply for service it ought to have been an untempered plate. This may be true; at all events, I am inclined to think the steel plate did the best.

The question now comes about plates for the future. I should suppose steel, in the long run, ought to beat iron, and I think there is a very simple consideration that would support that. When once steel shows both greater tenacity and will also elongate to a greater length before it gives way, I do not see how wrought-iron is to hold its own against it. The Royal Carriage Department give for ultimate tenacity best wrought-iron 22 tons, Landore steel (soft) 30 tons. Elongation, best wrought-iron 30 per cent., soft steel 33 per cent. If the steel has both greater tenacity and, when it gives way, elongates still more than the other, one does not see how the wrought iron is to hold its own against it. In boiler plates steel has replaced wrought-iron, and yet in boiler plates steel has the disadvantage of difficulty in welding at the joints; and what steel has done there, I should think, we may expect it will do eventually in armour. It may very possibly be that they may still have plates on the principle on which compound plates are made, but instead of being compounded of a steel front and a wrought iron back, I think it would have a soft steel back and a harder steel front. They say at Sheffield that they cannot get steel to behave as well as wrought-iron; but the question is whether, by-and-by, they will not be able to succeed even better with it. In the long run, it seems to me that steel ought to displace wrought-iron. I am expressing opinions for the sake of getting discussion; for I am anxious to invite the views of those who will say the opposite to this.

Now as to projectiles. In this country we have found our best chilled shot almost useless against steel-faced plates. There is an exception occasionally. There was a chilled projectile fired the other day at Shoeburyness, and I could almost wish it had not been fired. It did very well, and I believe it had no business to do as well as it did. I believe it was an exceptional one. They tell me from Sheffield that they have reason to think that that plate was not a good specimen. You must take that with a certain amount of reserve, coming as it does after an unsatisfactory result. Still, taking all into account, I think this result is an abnormal one. But, putting that on one side, generally speaking chilled shells have been reported to have slight effect against steel-faced plates; and, for the attack of powerful steel-faced

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armour, they report that it is absolutely necessary that steel projectiles should be used. At St. Petersburg and at Spezia steel-faced and steel armour has been knocked to pieces by chilled projectiles; and, looking at the diagram, you would conclude that at Spezia they have no right to say that chilled projectiles were of no use against steel-faced armour. It appears, therefore, that chilled projectiles, for some reason or other, have done better work against steel abroad than ours at home. The only way in which I can account for it is this: The Sub-Committee on Plates and Projectiles invited competition, and their competitive trial of chilled projectiles was entirely against wrought-iron. Our own chilled projectiles acted the best: they selected them and used them only against steel-faced armour. They would have liked to have had chilled armour to fire at; but, as a matter of fact, they only did fire our *own projectiles* against the steel armour. I think it is possible that the foreign chilled projectiles, though beaten by our own shot against soft iron, might have done better than ours against steel-faced armour. These are sketches from the actual effects of the shot. *Here* (Fig. 34, Pl. II.), you see the effect of a soft chilled projectile against wrought-iron: it sets up and does not get properly through. Fig. 35, Pl. II., again, shows the effect of a hard chilled projectile against wrought-iron; it breaks up, but its breaking up happens too late to interfere with its penetration. Fired against steel-faced armour they are under totally different conditions; the resistance comes on before the shot has the opportunity of getting its head in so as to receive support, and if you resist it when its point is only in contact, you throw a tremendous tensile strain upon it. In some very early instances Fairbairn discovered that a hemispherical-ended bolt crushed with less than half the pressure of a flat-ended one: the pressure acting on the apex of the former with a mechanical thrust like that which come on the sides of an arch. Hence all projectiles yield, but the English chilled shot shiver, sometimes giving a shower of unprofitable blows on a target's face (*vide* Figs. 36, 37, Pl. II.), while softer shot, though setting up, retain a larger mass of their heads, and deliver their work chiefly at the point of impact, and produces a better result than hard chilled shot. That is the sort of effect you get at Spezia (*vide* Figs. 38, 39, Pl. II.) from the chilled projectiles, which are rather soft; they get turned in *that* kind of shape. The cone is almost inverted, but they force a considerable mass of metal into the target; whereas our own projectiles are very apt to break and to strike in many places round the point of impact, making pretty deep but harmless impressions. I suppose that we shall have to get some more effective projectiles than chilled shot, even taking into account the Italian specimens. Sir William Palliser's improved projectile is one attempt to achieve this object. Here is a specimen. The idea is to have a chilled projectile and hold it together with a steel jacket, and to have the tensile power of the steel jacket to prevent the shot breaking up. He has not given up all idea of perforation because he has reduced the diameter, which is an advantage in firing at armour that he can make a hole in. The third feature of this shot is the rib for cutting or opening the plate. These projectiles have done well, I think, so far.

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At this moment our ships are furnished with chilled projectiles, which are very good against wrought iron; but I believe they would not be good against steel-faced armour, and perhaps they would be worse than almost any projectile carried by any foreign ships if they were fired against chilled armour, because in this they can make no hole, but merely break it in pieces. In 1879, some of us saw an experiment carried out at Meppen, the full significance of which I did not see at the time. Krupp had made what he called a Grüson chilled iron shield, and he made a wrought-iron shield of his own to compete against it. He began by firing chilled iron shot at both, but he was shrewd enough to perceive that his rival's shield, even when made by himself, was likely to do better than was desirable under these conditions; for the chilled shot broke with little effect on the former, while they cut deep into the latter. That would show that even foreign chilled shot are bad against chilled iron; and I should think ours are perhaps worse. The Whitworth have proved themselves the best steel shot; but Sir Joseph Whitworth refuses to make any more for us at present, and so does Krupp. At this moment we are badly in want of steel shot. The expense of developing steel shot is getting plates to try them on; and if the Admiralty try a great number of plates from time to time, it seems a pity to go on testing them with chilled shot which have been declared to be useless against them. I hope they will shortly try steel shot instead. It is a serious feature that we are not more forward in the manufacture of steel shot. At this moment the steel-makers tell me that they do not want to try 12-inch shot, but they want to try 9-inch shot. So that you can hardly say that we are in a position to make such shot as that for the 100-ton gun, unless Sir Joseph Whitworth would make them for us.

Now as to guns. *Since hard armour is destroyed by racking, the injury cannot be proportional to the power of perforation,* because the power of perforation depends on the total energy divided by a function of the diameter of the hole made in the plate. Where no hole is made, obviously *the diameter of the shot cannot affect the result,* and perforation tables may, in fact, give a very wrong impression. The breaking up of hard armour is proportional to the stored-up work of the shot. How different the stored-up work is from the power of penetration you may see from an example. Suppose you take Colonel Inglis' diagrams, you find that the 100-ton gun had about 24 inches of penetration at 2100 yards, you would find the 43-ton gun—our largest gun afloat, except in the *Inflexible*—at the muzzle would have about 24 inches penetration; and you might naturally say,—At the muzzle we have the same penetration that the 100-ton gun has at 2000 yards. Now, it would be a terrible mistake if you fancied that your power against hard armour was at all proportional to this, because, while the penetrations are nearly equal, the "*stored-up work*" is in about the proportion of 3 to 2, —that is, 31,200 foot-tons and 19,800 foot-tons. The 100-ton gun has, then, half as much again stored-up work as the 43-ton. That is the case when the 100-ton gun shot is striking with a lower velocity, namely, 1500 feet, while that of the 43-ton gun would have a velocity of 2000 feet. The shot striking at 1500 would probably hold much better

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together than the one at 2000; therefore it is a question whether the 100-ton gun would not produce double the effect of the 43-ton. Yet we have no diagram at present that would convey this to our minds. Any diagram that we have would rather leave a general impression that the 43-ton gun would have about the same effect as the 100-ton gun. For that reason it is specially important that we should recognize the difference between "*hard*" and "*soft*" armour, and should make experiments to investigate the matter.

There are one or two illustrations that I want to show you here with reference to stored-up work. There remains still the question as to the form in which destruction is effected, even when it is all done in shattering. A small portion might be broken up completely, or a larger part less completely, by any given amount of stored-up work. This is not a very easy question to investigate. I would take the well-known illustration of impact of solitaire balls in a groove, which I believe attracted a good deal of attention at Cambridge twenty-five years ago, which I have here reproduced on a larger scale. One ball dropped against one end of the column causes one ball to detach at the opposite end. Two let drop from one-half the height represent the same quantity of energy, but consisting more in weight and less in velocity, and you observe two balls detach themselves more slowly at the opposite end of the column. So with three or more balls. At first I argued to myself that this showed that stored-up work had a preference to maintain its own form; that if you struck a target a blow, consisting largely of weight and less of velocity, the effect produced would be more in mass and less in velocity. But now happened something which perplexed me. These sand shot are about three times the weight of the glass balls, and I thought that this one sand shot would have the same effect as the three glass balls—the same weight, the same drop. But the result is, as you see, instead of throwing up three glass balls at the end you only get one glass ball moved. I confess I did not see at once why it was. I used to be told that it depended on the balls being similar all along, but that is not the case; for if I put a glass rod between the balls we get the same effect. If you break the continuity by some totally different body it does not do so well; but with glass and iron it will do fairly well. Now, however, I will drop two balls in such a way that they shall only throw up *one* from the other end (experiment). The two balls you see are riveted together. The fact is, this does not show what I hoped it would show—it does not show that the work is going out in exact proportions of velocity and weight; but what it shows is, that when you drop two or three balls the impulses come in succession one after the other, and with three you get three successive impulses; therefore, I fear this illustration does not bear so much as I hoped at first as to the question of armour. It, at all events, shows that making up a shot's weight, by loose metal, as I have known done, is not the same thing as firing a heavier shot.

Now let us consider the case where the resistance is the resistance of cohesion and not of inertia. Those two guns are loaded, one with a marble and the other with a bullet about three times the weight of

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the marble. They have very small charges—one as little as two grains. They are so adjusted that they make about the same impression on impact on soft millboard. But if you fire them at hard glass, the one that goes with the lowest velocity gives the glass time to transmit the effect a little bit around the point of impact, and so, generally, to make a larger hole. We all know that if you fire a bullet at a pane of glass you make a round hole; whereas if you throw a stone slowly you crack it up. (Experiment.) The point here is, that the same stored-up work in the two cases generally produces the different effects above-mentioned.

Alexandria Bombardment.

In conclusion, I wish to offer a few remarks about the Alexandria bombardment. The *Invincible* (Flagship) and *Penelope* engaged at anchor in the outer harbour against earthworks at from 1000 to 1500 yards range. The *Monarch* acted with them under steam, as well as eleven gunboats. The *Temeraire* supported the attack from the central pass into the harbour at about 3500 yards range, and the *Inflexible* in the corvette pass divided her fire between earth and masonry forts up to a still greater range. The *Alexandra, Superb,* and *Sultan* engaged masonry forts chiefly, at first under steam, at from 1500 to 1900 yards, and at length closed in and anchored at 800 yards. The ships suffered only from shells entering unprotected places, and so killing men. Their armour was not pierced at all. The forts carried some guns capable of piercing nearly any vessel's armour if a full direct hit were made. A 10-inch gun might pierce any of the ships except the *Inflexible* up to perhaps 1500 yards range. Any hits then made by the more powerful Egyptian guns must have been very indirect. Again, it does not appear that any ship suffered any casualty when in motion. This argues something for the advantage possessed by ships engaging forts. But we must remember that the Egyptians, however brave, were not scientific gunners, and were suffering under an overpowering fire. Average success was not to be expected under these conditions. Further, the low elevation of the batteries above the sea was greatly in favour of the ships; so, of course, was the absence of submarine mines and torpedoes. If we wish to consider what our Fleet might effect against a well-fortified harbour, we ought to suppose the case of earthworks with more command than those at Alexandria. Under such conditions, vessels could not draw up inside a harbour and make the simultaneous attack that took place at Alexandria, nor could they move freely about like the *Monarch* and gunboats. They might have to feel their way and anchor in water that had been ascertained to be clear of mines. Anchoring would render them liable to be attacked by mortar fire. It is recognised abroad that the moment a ship anchors it is liable to be attacked by mortar fire. I have mentioned here two or three times that I saw Krupp, at four miles, drop five rounds out of ten into a marked space about the size of the *Inflexible's* deck. You will see what a formidable attack this is for vessels at anchor. I believe myself that as long as they are in motion they need

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not mind mortar fire; but as soon as they anchor they suffer from it if well directed. In these days of sub-marine mines it may sometimes be necessary for ships to anchor. In the contemplated expedition against the Russians in the Baltic a few years since, the instructions were that our ships were to anchor in cleared water and so engage the enemy. Anchoring would render them liable to be attacked by mortar fire, and forts with high command might attack their decks with guns, especially when lying head-on. On the other hand, the Fleet at Alexandria consisted chiefly of broadside vessels, and we ought to credit the fleet with the presence of ships like the *Thunderer*, *Devastation*, or *Dreadnought* (none of these were in our Fleet. Except the *Inflexible* we had only broadside ships.). The *Thunderer* class are completely protected and have heavily-plated decks; and possibly there might be vessels of the *Glatton* and *Gorgon* class which, besides being well protected, are able to enter shallow water. Nevertheless, forts of iron and earth would generally hold out a long time, unless extraordinary fire was concentrated on them. In any cases, the Fleet must be furnished with a very large supply of ammunition to attack a well-defended harbour. Finally, one word to connect this with what has been said before on hard armour. Grüson's chilled iron is now to be found in coast forts in Russia, Germany, France, Holland, Belgium, Spain, and Portugal. Not three officers in England have ever fired a shot at it. Perhaps eight officers may have seen Krupp's imitation of it receive a few shots at Meppen. In this country we have never tried it. How is it to be attacked? Probably direct impact and weight are the most telling elements in an attack. Hard armour throws shot off striking obliquely very well, and light shot with a high velocity might shatter themselves against it, and it would be difficult for ships to hit the same spot repeatedly. Look at the turret and other figures of Grüson's forts. The curved form of all, and the movements of the turrets render the task very difficult. There are some on the entrance to Antwerp, and looking at them you will see that they are very ugly things to fire at. The question is how to attack forts of that sort. Perhaps with a number of moderate-sized guns the best hope would be to fire at the glacis, which, I believe, may be crushed gradually by shot glancing on it, and so a breach might be made; when the fixed wall, of comparatively slight thickness behind it, might be struck nearly directly. Colonel Inglis has suggested that one shot of overpowering weight might injure such a fort very greatly; because, instead of passing through and leaving a moderate-sized hole, as in wrought-iron, the power of the chilled metal to transmit the shock through its mass might cause the shield to absorb all the energy of the shot, and so suffer wholesale ruin. On this principle, the *Inflexible* might destroy a chilled fort as quickly as a whole fleet of other ships. This is another argument in favour of heavy guns. These speculations, however, only remind us of the great need indicated throughout this paper—*the need of experiments against hard armour*.

To say briefly what I believe are the points that are brought to our attention in the last year's experiments, they are these:—that it is very important in this country that we should recognize the difference

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between *hard* armour and *soft* armour—armour that can be perforated and armour that cannot be *perforated, but has to be destroyed by breaking up*. New type guns, I believe, are what we require for immediate purposes to hold our own against the wrought-iron ships that exist; but for the future we have to consider the case of *hard* armour, and we shall then require the gun that will produce the most stored-up work. The stored-up work is enormously more in a large gun. You cannot make it up in any way in a small gun, and that appears to me to be an argument in favour of large guns. Then we require experiments against chilled armour to see what our service shot will do against it, and also to develop the most suitable sort of shot. I think that is the main point I have to suggest to-day, and that I hope will be discussed—the necessity of our recognizing that in this country we want experiments very much against hard armour. I said this at the United Service Institution a few weeks ago in order to see what Mr. Barnaby would say, and Mr. Barnaby in his reply said that he felt that experiments are very much needed against hard armour.

THE CHAIRMAN.—I am sure we have all listened with a great deal of interest and advantage to Capt. Orde Browne's lecture. With regard to what took place at Alexandria, he no doubt considers it as a trial of materials then in use; and to which, apparently, in Artillery matters, we are about to say good-bye. He has cast his eyes forward, and as you look forward, each subject, after you become acquainted with it for a little while, opens into other subjects; and now he is dividing the armour into hard and soft. I dare say soft armour and hard armour will each be divided into parts as we go on. I hope we shall hear the opinions of some officers on these two branches.

CAPTAIN PALLISER.—It may not be known to you that an experiment was made on Thursday week at Shoeburyness with a newly designed shot, something like that specimen, which appeared to interest the officers in charge of the experiments very much. It was made with a shot designed for the 80-pr. gun for the Australian Government, who asked if we could make that an armour-piercing gun to introduce a particular description of shot into their service. The Australians accordingly purchased a 6-inch compound plate from Cammell & Co.; I purchased a similar one, and these plates are to be fired at next week. The trial to which I refer was only preliminary. I asked the Committee to be so good as to fire at a wrought-iron plate. The object I had in view was first of all to ascertain the forces that destroy the shot when they try to get through a plate. Take the common form of shot, this is how they act (referring to diagram). You call that force A. *That* is the resistance of the plate on one end, and the great mass of the shot pushing on the other makes a great force to bear *here*, which in a steel shot bulges, and in a chilled shot crushes. The force of B acts that way from the nipping of the plate, this you will see exemplified *here*; that shot has not been broken by impact but by the nipping of the plate. The only way to except those forces was, I thought, to support the shot if possible *here*, and to taper the shot, and then I came to this description of shot with the jacket on it; and these were fired at a 4-inch compound plate, which I purchased, and which was set up at Shoeburyness and behaved very well. I thought I ought to fire them at a heavier plate in order to discover their faults, and I therefore purchased a 5-inch compound plate. I found this extraordinary result: the jackets dashed forward with an extraordinary impetus, so great as to sheer off *this* shoulder generally: *that* was sheered clean off as if by a tool. I at once saw that an enormous deal of work was lost on the shot, and that if I could utilise that work so as to get the work done on a point

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I should get good results. I designed the jacket (referring to diagram) I proposed to push this jacket on with hydraulic pressure, but then it struck me that if I fired that at a compound plate, supposing the head does enter as soon as it gets as far as *that*, the whole of my jacket will come off, and the force will be lost, so that it struck me I should, if possible, utilise the enormous force which I knew lay stored up if I could only get at it. So I lengthened my shot and reduced my jacket (referring to diagram); this is going to be tried next week. Here we have the 80-pr. shot with this jacket on it, pushed on, and the tendency to dash forward being stopped by the base of the ribs on the one hand, and also by a stop which I constructed *here* to catch this, and also by this very heavy base which I hoped would act as a ram. I went to Shoeburyness last Thursday week and said to the Commandant, "I have come here to trouble you to see whether this jacket will crush when the shot reaches the plate and give the advantage of this ram; if it does not crush, I shall send the remaining shot back to the works, and still further reduce it *there*;" the gun was loaded with 20 lbs. of pebble powder and fired at a 9-inch wrought-iron plate: the result appeared to surprise the officers, the shot went clean through without breaking, the jacket crushed up completely, and *this* ring was found lying in front of the plate; the same description of shot, only of a better class are to be fired on this day week at Shoeburyness, and it will be very interesting to see what they will do against 6-inch compound plates.

THE CHAIRMAN.—What is the composition of the jacket?

CAPTAIN PALLISER.—Soft steel, untempered; I have steel shot made in the same way only without ribs, so that exact comparison will be made. I am going to ask the Committee to fire at my plate; that probably would stop the shot, and I am going to see if we cannot make further improvements.

ADMIRAL BOYS.—It is with considerable diffidence that I rise to-day, because not holding any official position at present, I am rather behind hand in what is going on. There are, however, one or two questions I should like to ask Capt. Orde Browne. We must, I think, consider two special points beyond everything else—to make everything as light as possible and as cheap as possible, for I am sorry to say with our Government everything is a question of money, and we certainly do not get sufficient money to carry on experiments to verify these difficult questions that are now before us. I am sorry to see what Capt. Browne tells us, that on defensive points other countries are getting ahead of us. I should like to ask a question with regard to chilled projectiles, namely, whether you are able to get a shell through chilled iron so as to burst inside,—whether that is really found to be practicable. It has been done in several cases, but I should like to know whether we have actually got a large powerful chilled shell through a thickness of armour, and burst the shell inside.

Capt. Browne also referred to the case of the Bombardment of Alexandria. I have not had the opportunity of consulting any one else about it, but it appears to me that at that bombardment we had exactly the gun that we required for the work it had to do, and for the following reasons:—The enemy had precisely the same gun as we had. As a rule the ranges were limited to somewhere about 2000 yards, and I believe at that range our muzzle-loading guns employed there were practically equal to any breech-loading guns that might be found anywhere. The shell carried a very high bursting charge; we did not require high velocities, because we had no armour to penetrate, and therefore although I am perfectly certain that we must have breech-loading guns, I think for the work we had to do at Alexandria, the muzzle-loading guns were quite equal to everything required.

Capt. Browne has also referred to ships engaging forts under weigh and at anchor. I quite agree with him that it would be most dangerous with good gunners and good mortars to anchor ships for any length of time; when the range is once obtained we know that some Foreign Powers carry their mortar batteries to

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extreme accuracy, and I have not heard myself that we have been proceeding in that direction at all. I think however that the question of engaging at anchor or under weigh, must be left entirely in the hands of the officers who are in command of the Fleets; having regard to all the circumstances and conditions of the enemy, we cannot lay down any law one way or the other; we had one very large ship at Alexandria, and we had not the disadvantage of either being hampered by torpedos or by mortar fire. Of course we all know the work was done as well as it could be done, but I think we also had good guns, and we did not require the ships that Capt. Orde Browne has mentioned, the *Thunderer* and the *Glatton*. I think also it was found that the fire was more effective from the numerous smaller guns than from the very heavy single projectiles of the *Inflexible*, or of the other ships referred to. During the American war, at the Bombardment of Fort Sumter, I was given to understand that the gunners feared the continuous fire of the smaller guns far more than the slower fire from the heavy guns. Continuous rapid fire was more effective on these occasions than the fire of heavy guns.

MAJOR CAMERON.—I should like to ask Capt. Orde Browne if he can give us the relative price per ton of these two 9-inch projectiles, the Whitworth and the Terre Noire, because I suspect that the Whitworth was very much the dearer of the two.

LIEUT.-COLONEL BAYLY.—I have been asked by General Smyth to say a few words with regard to the experiments in the high-angle fire of rifled howitzers lately carried out under the Ordnance Committee at Dungeness. The 8-inch and 6·6-inch howitzers were tried at high angles of elevation, at ranges extending up to 2400 yards, and the results obtained certainly exhibited considerable accuracy, especially in the case of the former piece.

I did not come here prepared to speak on this subject, and cannot, at the present moment, call to mind the exact per-centage of hits obtained within the small areas practised at; but I think I can safely state that these pieces exhibited such an amount of accuracy that, had their fire been directed against vessels at anchor within the range named, not inconsiderable results would have been obtained, especially if the vessels had been lying end-on to the battery.

I should like to take this opportunity of making a few remarks, to refer briefly to the experience recently gained in the matter of breaching formidable earthworks by artillery fire, because I think it is a subject likely to interest the officers present. As far as the experiments carried out by the Ordnance Committee have gone, it would appear safe to conclude that, for the purpose indicated, the two essentials are accuracy and shell-power, and that, possessing these, the most formidable earthworks may be breached within a comparatively short space of time, provided always that those working the guns are in a position to enable them to arrive at a correct estimate of the point of impact of their projectiles. Now, it is obvious that the heavy guns of the Royal Navy are possessed of ample shell-power, but formidable obstacles often intervene and detract from accuracy of fire: I refer to the fact of the guns being on a moving platform, and being not infrequently directed against objects in themselves indistinct and more or less obscured by smoke.

Then again, when several guns are firing simultaneously, it is next to impossible to attain to correct observation of the effects of fire, or, in other words, to note the point of impact of their projectiles, and on this elevation and range are dependent.

We know ourselves, even when firing single guns from a stable platform at a known range, and laying "reverse" at a well-defined object in rear, how very difficult it is to arrive at a true conclusion regarding the point of impact, even at such ranges as 1200 or 1500 yards, and the consequent difficulty in securing the amount of accuracy desirable. Therefore, when we come to consider the conditions under which the fire delivered against the Forts at Alexandria was conducted, it is a matter of surprise that the fire of our ships was as accurate and effective as it would

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appear to have been, judging from the reports that have reached us of that decisive engagement.

COLONEL INGLIS.—I am not sure that I have much to say that will interest the meeting, and what I can say will be almost altogether in confirmation of Captain Orde Browne's paper, which I think is an excellent one. This question of hard and soft armour is a very important and interesting one, especially with regard to the last results that have been obtained, for the trials at Spezia and St. Petersburg appear to be contradictory, and require a good deal of consideration. At Spezia the steel seems to have done much the best, whereas at St. Petersburg the compound armour has beaten the steel. I suppose there will be an explanation of it. That first round fired at the thick steel plate is a very remarkable one, not a single crack is observable, though possibly there might have been cracks, because one seems to have been developed at the next round. The explanation seems to be this—that there is a certain blow which steel can stand perfectly well without showing any signs of cracking, but the moment you get beyond that it goes in star cracks. From our late experience at Shoeburyness, we have found that the 18-inch plates go all to pieces at the first round from the 43-ton gun, as in that second round at the Schneider plate. The difference of effect upon a compound plate is pretty easily to be explained, that is, the steel presents a much harder and stronger column of material to the shot, and, therefore, it does not compress in the same way that the compound armour does under the pressure of the steel on the wrought-iron backing, which causes that circular cracking which you always observe in compound plates. Captain Orde Browne said, that because you test steel and find in it greater power of elongation and tenacity, therefore steel must operate as a better material for stopping shot than a softer material. I go with him to a certain extent in that, but I do not think you must go simply by the tests that you get in the test machine, for they are fallacious in matters of impact of shot. If under suddenly applied blows, such as by a falling weight, you can get greater elongation and tenacity and greater ultimate strength out of a piece of steel than you can out of a piece of iron, then I say decidedly that steel must be better for armour than the iron; but the same does not follow in the case of testing under gently applied pressure. Therefore I do not think Captain Orde Browne's argument will quite hold good, and I shall always advocate the testing of all this material in a way which, as nearly as possible corresponds with the action that takes place when it is struck by a shot, that is to say, by suddenly applied blows: a weight falling some twenty or thirty feet is a very fair approach to that kind of effect.

Just one other point: I think Captain Orde Browne did not quite represent what took place at our Sub-Committee trials. We did not attempt to decide the best nature of material for projectiles by trials of soft iron only; we went through a very lengthened series of experiments during 1878–79–80 with steel plates and compound armour—both with direct and oblique fire. There were three steel-faced targets that were compared with wrought-iron in every possible way, and we judged of the merits of the projectiles principally from their effect upon steel-faced armour.

CAPTAIN ORDE BROWNE.—I spoke of the competitive *chilled* shot. I understood that with steel-faced armour you tried different sorts of *steel* shot but only one chilled shot. I was comparing our *chilled* shot with foreign *chilled* shot.

COLONEL INGLIS.—We were comparing the best chilled shot the Laboratory could make with different kinds of steel shot against both hard and soft armour.

CAPTAIN ORDE BROWNE.—We considered that our chilled shot was the best chilled shot, because it was the best chilled shot only against *soft* armour.

COLONEL INGLIS.—Then, with regard to the question of the use of chilled cast-iron for defensive purposes. I am aware that there are upwards of a hundred guns

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mounted on the Continent behind armour of that description, and it appears at first sight rather singular that we should be so much behind the rest of the world in experience of that material. Just to show, however, that it has not been altogether overlooked in England, I may state that so long ago as in 1867 we fired at blocks of chilled armour at Shoeburyness with the 7-ton gun and the 68-pr.; and it showed quite enough of its hardness; we could not make any impression upon it, but it cracked very much. The matter has not been followed up in this country for one reason which I think I may as well mention at once; neither Grüson nor any of the advocates of chilled cast-iron would attempt to make a shield of that material for a gun unless it were muzzle pivotted; they could not possibly afford to make so large a hole in a shield of that material as we have been obliged to make in our armour; and another thing is, that you cannot have that form of structure, that is, the slanting curved form, so long as you have muzzle-loading guns. For years we have been driven to the use of vertical armour, because of the extreme difficulty of arranging for the service of a muzzle-loading gun behind anything like a sloping structure. It has been difficult enough to give the requisite space for the service of the gun with vertical armour, but with sloping armour it becomes quite an impossibility. Therefore Grüson lays it down—and everyone on the Continent lays it down—as essential, that you must not only muzzle pivot your guns, but you must have breech-loaders also for cast-iron defences. Now that we have at last arrived at breech-loading in this country, we shall not think of putting up vertical armour; we shall have sloping armour. Therefore now the matter to consider is this, can you for a given sum of money give better protection by means of hard chilled cast-iron than you can by sloping faces, of, we will say, steel-faced wrought-iron, or steel? And that is the point, I think, to which we must now look. When I went to the Fort to which Captain Browne referred, on the Scheldt, three years ago, I certainly liked the look of it very much. I discussed the matter with the officers there, and they gave me every information. I got the price, and all the difficulties attending its construction; and then it appeared plain that the question to be decided by experiment—and it can be decided in no other way—is whether for a given sum of money we can put up a structure of, say, compound-armour plates, or even wrought-iron armour plates, at a great slope, that will for the same money stand as much as one of these cast-iron structures. Of course, the trial must take place with crushing blows, because we know that cast-iron is very good when it is not overpowered, but the moment it is overpowered, you cannot answer for it, it collapses altogether. I said to one of the Belgian officers there, "How would you like the face of this work to be struck by a blow carrying about 25,000 foot tons of energy?"; and he shrugged his shoulders. I am quite sure he thought one such blow would breach the work. With sloping surfaces of other armour, I am pretty certain we can beat that construction. The only obstacle to the experiment is the difficulty of getting the money for it.

Captain Orde Browne.—I think there is nothing that calls for reply in what Captain Palliser has said. With regard to what Admiral Boys has said, I am very glad to have the opportunity of removing a wrong impression as to my conclusions, namely, that Foreign Powers generally are ahead of us in all these things. I did not mean to say so much as that; I wanted to call your attention to any particular matters in which I thought they were ahead, but I did not intend to say that this was generally the case. For example, look at the Spezia trial before us, two out of the three species of armour were supplied by England, the gun was supplied by England, and the best projectile, if it was not actually a Whitworth shot supplied by England, at all events was a copy of one, therefore I do not think we are in a position to say that other nations are ahead of us. But I think there is quite enough to make us watch seriously. Colonel Inglis has spoken of the St. Petersburg results contradicting that obtained at Spezia, but unfortunately the contradiction is on the 12-inch scale, instead of on one of 18 inches; and when we know the Schneider

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18-inch armour was made under 100-ton hammers, we cannot help feeling that that may argue a perfection of manufacture on a large scale, which is a serious thing, and one that ought to be watched; and the same way with projectiles. Our steel makers, now that Whitworth has withdrawn, are requesting to have plates given them in order that they may try 9-inch projectiles before even dealing with the 12-inch ones. If the 100-ton projectile before us was a foreign one, all you can say is that it is a magnificent copy of the best English steel projectile. This surely should make us stir ourselves, for it is the scale on which the thing is being conducted that I think calls for attention. With regard to "hard" and "soft" armour: I have never heard anybody speak of "hard" and "soft" armour in the way I have been speaking of it to-day, but it appears to me it requires to be divided in that way. I know Captain Noble, of Elswick, speaks very strongly about it; he even spoke of it as a thing people ought to have seen long ago, that the work done against hard armour was not in proportion to power of perforation, but to "stored-up work." In calling attention to chilled iron armour, I am not speaking of that class of armour as armour that I should like to see introduced indiscriminately, but I should certainly like to know the effect of shot against it. As a matter of fact, I believe there is a great deal to be said for our own coast plate-upon-plate armour compared with chilled, because you see the resistance of that armour depends on its being one homogeneous mass; and the work being distributed through it. Up to a certain point it will absorb a blow fairly, but get beyond that point and it shatters on a very large scale. There is this feature also about it, namely, that it does not admit of any growth. We have various forts at Portsmouth and elsewhere, which not only admit of being added to, but there is every provision actually made for adding to them. You cannot add to chilled shields, they are final as to magnitude; you must pull the whole fort down and put up a new one instead, if you want a stronger one. There is then much to be said for our forts even in their present condition, and of course they would be better if they had steel faces put on in front of them. What I believe we want is to see the chilled armour fired at in this country, in order that we may have some idea of what our projectiles will do against it, especially if our chilled projectiles happen to be singularly badly suited to injure it, as I am inclined to believe they are. With regard to the price of the Terre Noire shot I do not know that that matters very much. Supposing they charge the same for them as for the Whitworth, it still shows the possibility of making the shot very well abroad, even for the 100-ton gun; and as I say, we are rather puzzled at this minute how to make them for the 43-ton gun.

Admiral Boys asked if we had really succeeded in getting a steel shell through plates always, so as to burst inside. This problem is at any time only possible with soft armour. I believe from the reports that certain individual shells on certain occasions have got through wrought-iron in such a way as to burst inside. I believe it is very far from a certainty. It is only that there appears to be a possibility of doing it as a future thing. But even suppose success was ensured, we may say, "I do not much care whether you can get it through or cannot; if you can get it through it simply means this, that we must take to hard armour instead of soft:" and that is why I lay stress on hard armour, as a sort of armour that we require to make experiments against. In the form of steel-faced or steel armour, I suppose all those who have gone into the question would say it was the best sort of armour we could have. In the case of chilled armour, price is a consideration; but whether it is chilled, or whether it is steel, hard armour has to be dealt with, not by perforation, but by a smashing blow proportionate to stored-up work, so it appears; but we require to make experiments in order to know certainly how to deal with it.

THE CHAIRMAN.—I am sure you will empower me to give our hearty vote of thanks to Captain Orde Browne for his lecture.

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FIG.12

5TH ROUND-2ND ROUND AT BROWN'S PLATE

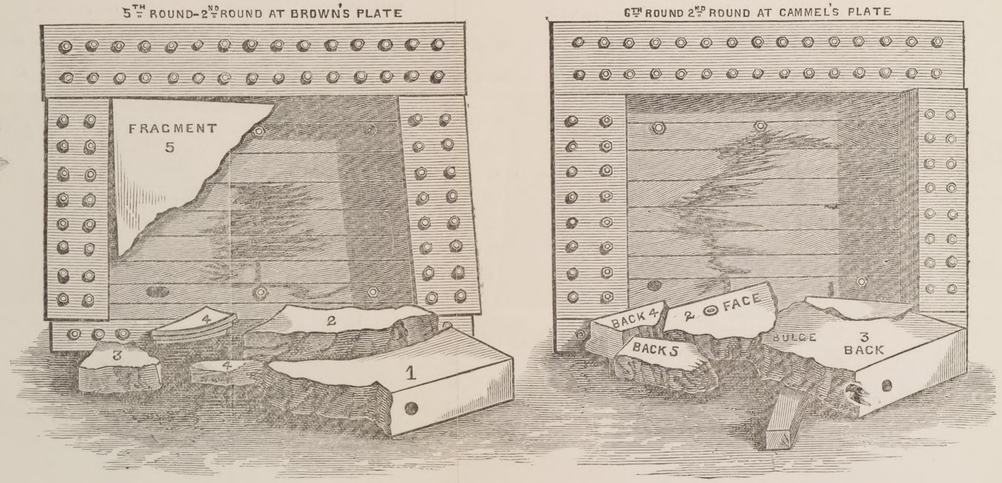


FIG.14

6TH ROUND 2ND ROUND AT CAMMEL'S PLATE

SHOT POINTS FROM BROWN'S PLATE

FIG.18
ROUND 2

FIG 17
ROUND.1.

FIG.24

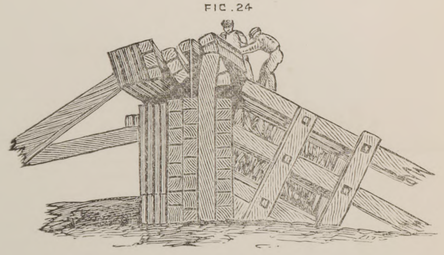


FIG.26

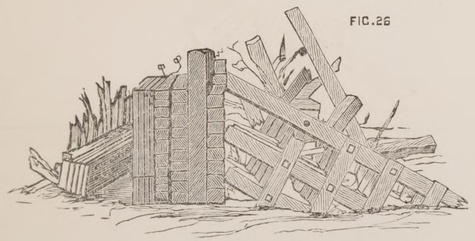


FIG.25

8TH ROUND. 4TH ROUND AT SCHNEIDER'S. PLATE

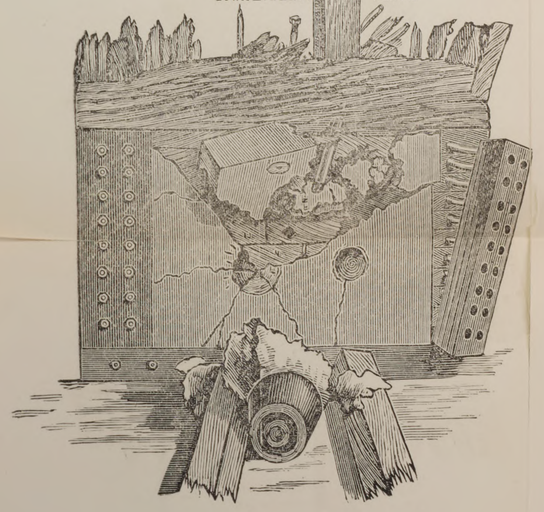
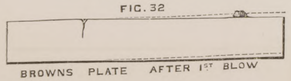
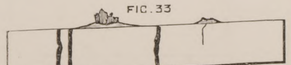


FIG.32



BROWNS PLATE AFTER 1ST BLOW

FIG.33



SCHNEIDER'S PLATE AFTER 2ND BLOW

FIG 31

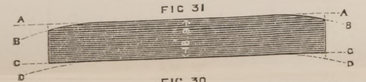


FIG.30

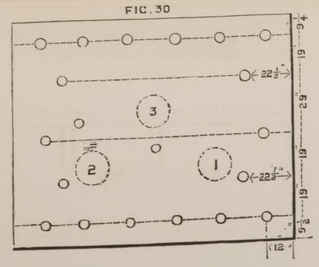


PLATE I.

FIG.1

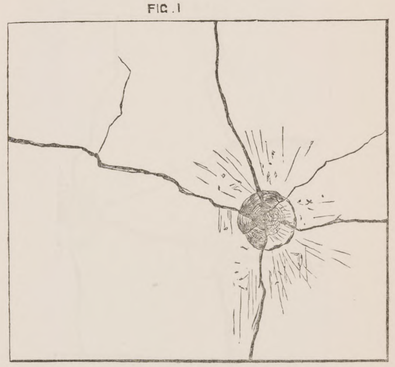


FIG.2

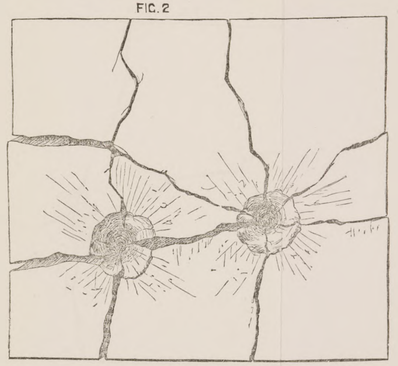


FIG 3

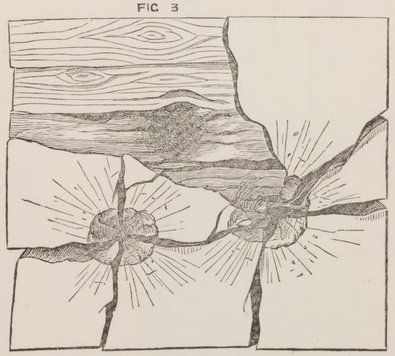


Fig 3.a

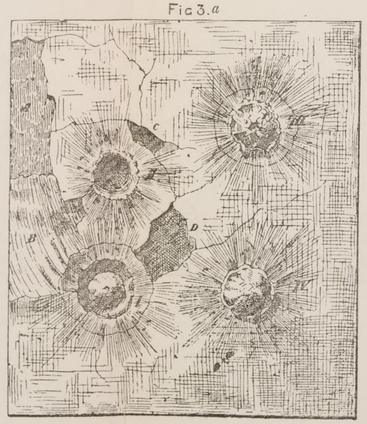
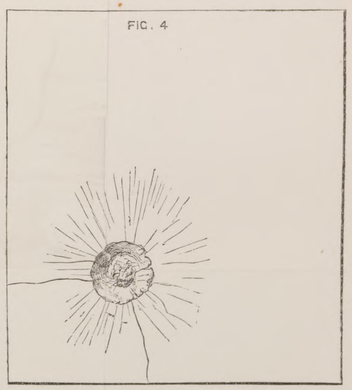


FIG. 4



HORIZONTAL SECTION
FIG.2

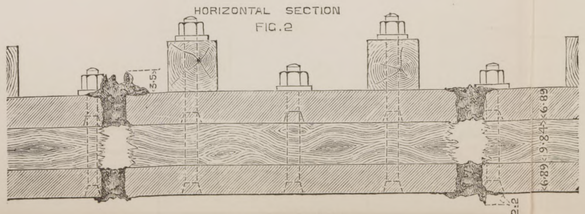


FIG.3 FRONT VIEW

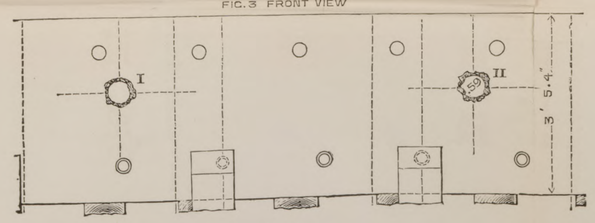


FIG.6.

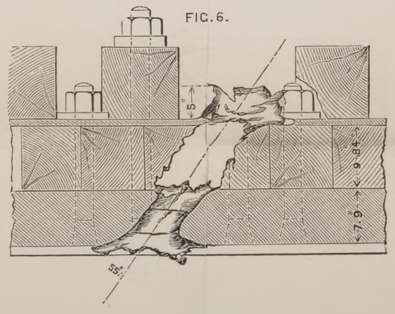


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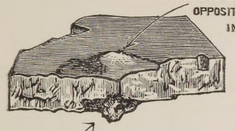
PLATE II.

FIG. 16.



POINT OF SHOT SET & FLATTENED INTO CAMMELLS PLATE. ROUND. 2.

7TH ROUND. 3D ROUND AT SCHNEIDER'S PLATE.
FIG. 19.

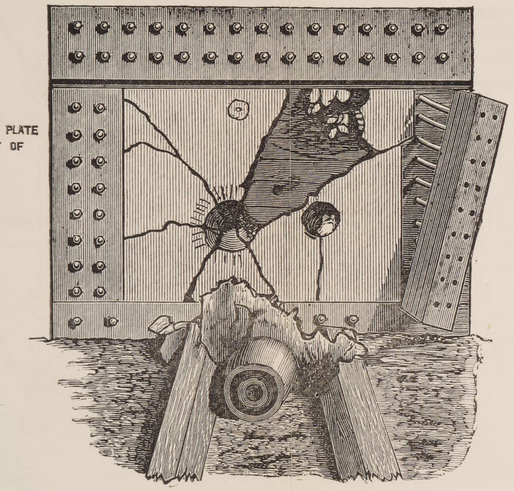
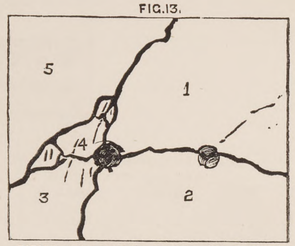
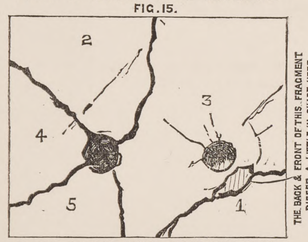


FIG. 13.



PIECES OF BROWN'S PLATE ASSEMBLED.

FIG. 15.



THE BACK & FRONT OF THIS FRAGMENT DIFFER A LITTLE IN SHAPE HERE.

PIECES OF CAMMELL'S PLATE ASSEMBLED.

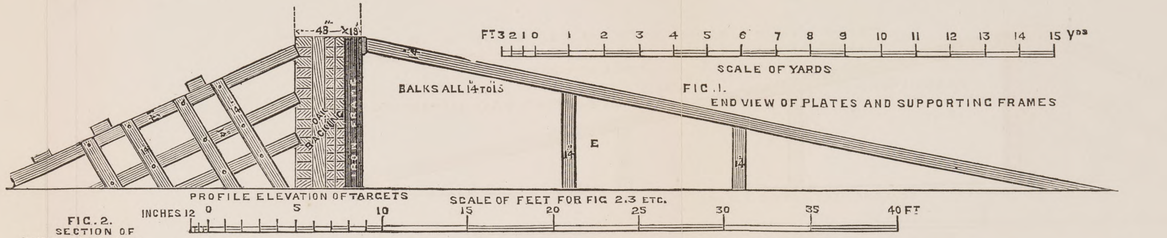


FIG. 1.
END VIEW OF PLATES AND SUPPORTING FRAMES

PROFILE ELEVATION OF TARGETS

SCALE OF FEET FOR FIG 2.3 ETC.
INCHES 12 0 5 10 15 20 25 30 35 40 FT

FIG. 2.
SECTION OF PLATE AND BACKING

FIG. 3 FRONT ELEVATION OF COMPETITIVE PLATES

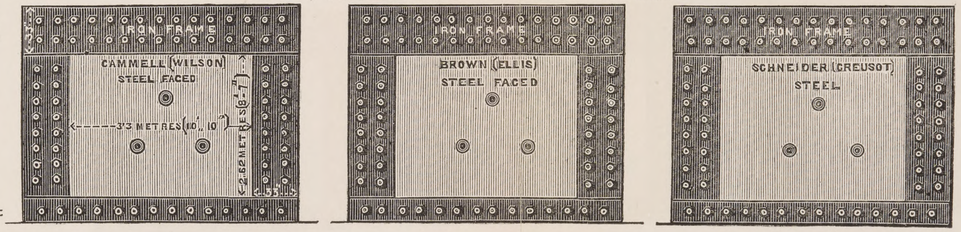


FIG. 6
ROUND Nº 3
FIRST ROUND AT BROWN'S TARGET

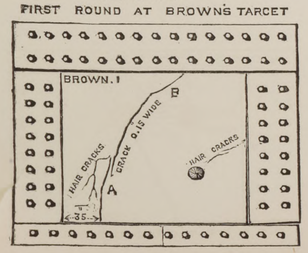


FIG. 7
ROUND Nº 4
SECOND ROUND AT SCHNEIDER'S PLATE

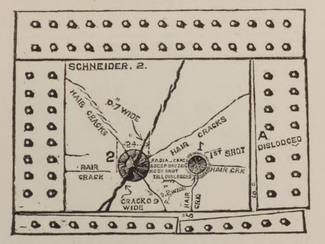


FIG. 9

POINT OF Nº 2 SHOT DISLODGED FROM HOLE. VERY LITTLE APPEARANCE OF SHILL

VIEW OF SHOTS HEAD FROM A. FIG 7

F.C.8

FIG. 11
BACK OF SCHNEIDERS PLT

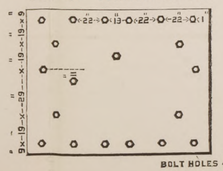


FIG. 10
BACK OF CAMMELS & BROWNS PLATES

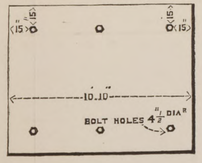


FIG. 4
ROUND Nº 1
FIRST ROUND AT CAMMELL'S PLATE

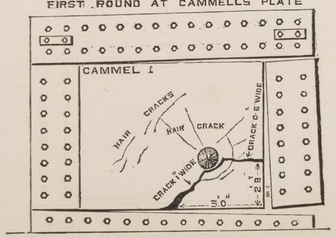


FIG. 5
ROUND Nº 2
FIRST ROUND AT SCHNEIDER'S PLATE

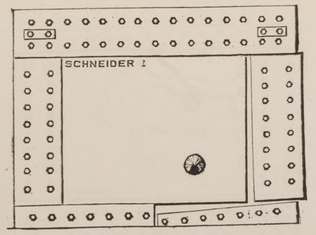


FIG 29

FIG 21

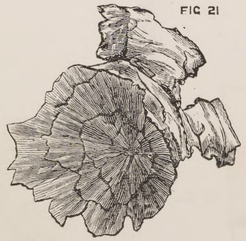


FIG 23

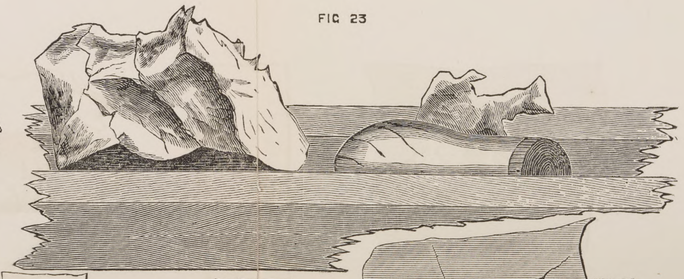


FIG 22

FIG 20

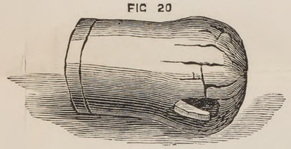


FIG 34

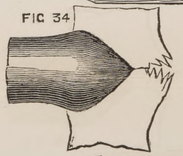


FIG 39

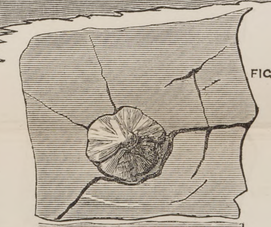


FIG.38

FIG 35

FIG 36

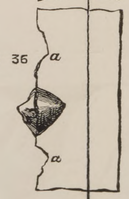


FIG 37

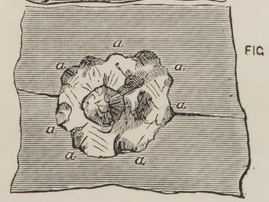
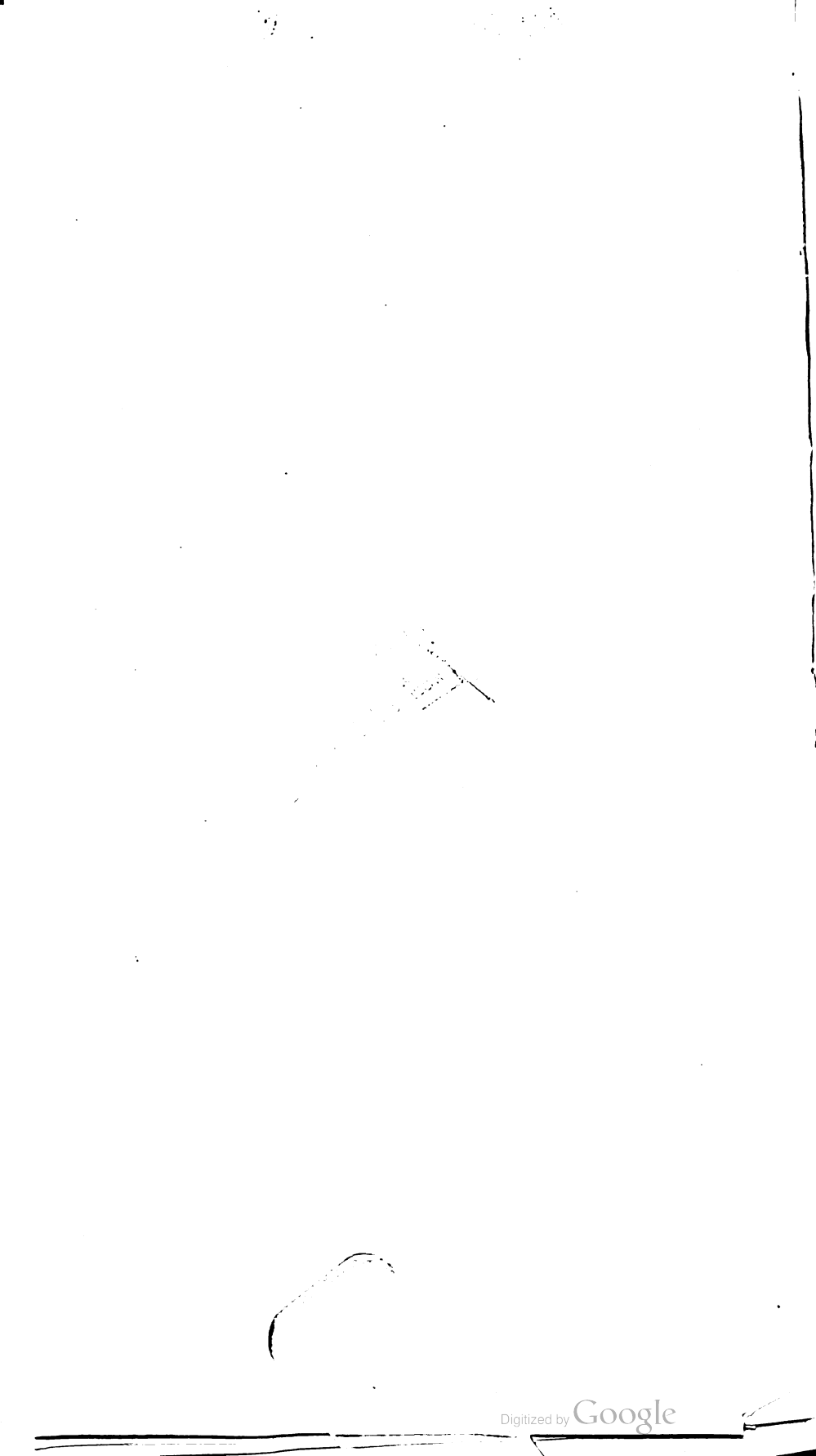


FIG 28

FIG 27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CASUAL NOTES

ON THE

GERMAN INFANTRY AND FIELD ARTILLERY.

BY

MAJOR A. T. WODEHOUSE, R.A.

I WENT to spend the latter part of my winter's leave in Germany, and arriving at Altenburg (Saxe-Altenburg), my first destination, on the 26th February, 1883, found that I had arrived there at a peculiarly interesting time to the military observer, viz., that at which the recruits, enrolled on the 1st November, were undergoing their inspection, passing them as fit to take their place in the ranks by the side of their older comrades.

Altenburg is the Head-quarters of the 96th Regiment of the Line, one Battalion of which is stationed there. The inspection of the recruits by the Colonel Commanding the Regiment lasted the whole of the 26th and 27th, lasting each day from 7 a.m. till 7 p.m., with an interval of one hour for dinner from 12 till 1. The time after dark was utilized for indoor examination.

The inspection was a most searching one. The recruits of each Company were separately paraded under their own Officers, and put through the whole of their drill by one of the Subalterns. It began with each man marching by himself right across the barrack square in slow time and then in quick, and after being drilled in small squads at marching, manual and platoon exercise, and finally by Companies: the crucial test of training was reached by their advancing or retiring in skirmishing order, and then being suddenly ordered to form on either flank in close order, fronting in any named direction, done at the double with great smartness.

I could not help being struck at the high pitch of training to which the men had been brought in the short space of four months, and though I will not here make any comparisons between the drill of the German and British Infantry, I should ascribe the great success of the former to the following prevailing conditions:—

1. The recruits all join on the same day throughout the German Army, so that not only is the time of the Instructors employed to the best advantage, but with a fair start a healthy emulation is created throughout the Army, and no excuse can be of avail for one Regiment being worse drilled than another.
2. The drill is carried out under the immediate supervision of the Company Officers, and Army Form B 91 being unknown, the Officers and N.-C. Officers know that their care and labour will be for the credit of their own Regiment and not of the Army at large.

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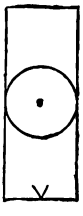
3. They are subjected to a most severe course of drill, lasting all day long every day, Sundays excepted; and if they find it irksome, they cannot desert or malinger, and being actuated by a high soldierlike spirit, would disdain seeking relief from their burden by either of these means.

The drill, though excellent according to the lights from which I viewed it, did not apparently satisfy the Colonel, as from the house where I was living, and which overlooked the barrack square, I could see that the elementary drills were continued after the 1st March: whereas, on arrival at Berlin a few days after, I saw that other Regiments had reached the second stage in which the recruits are incorporated with the older soldiers, and the Captains begin to attend more in person to the drill.

The smartness, rapidity, and precision required of the German soldier in every motion of his drill are very striking; and the system of drill is such that the process of making him into a military machine and the development of his intelligence are carried on at the same time. For instance, in the Company drill there seem to be no executive words of command, but the soldier has to think for himself how the evolution in hand is to be carried out. I saw a Squad or Company form Column of Sections in rear of the left, without any further executive word of command, at the double, and re-form line in the same manner.

By the courtesy of the Adjutant and one of the Subaltern Officers, I was enabled to see a squad of recruits at the first stage of rifle practice. 5 rounds are fired by each recruit at a range of about 120 yards, at a white target 6 feet high by 2½ feet wide, with a black line about 3 inches wide down the centre. The firing at this stage is over a rest which is not used at any subsequent stage. The recruit has to hit the black line three times out of the five, to qualify him to proceed to the next stage of practice. Of 60 recruits that I saw shoot belonging to my friend's Company only 4 failed in this test. I thought the performance a most remarkable one for men whose whole military instruction had been compressed into four months in the depth of winter. The method of aiming is worthy of note. Both German Infantry and Artillery aim at the bottom of the target, the pieces are so sighted that if aimed correctly the shot strikes the target a little below the centre.

The recruits practice being over, a party of older soldiers arrived on the ground, commenced firing their five rounds each at the same range, but without a rest, and at a target of the same dimensions as the other, but with a circle inserted a little below the centre, instead of the black line down the middle: all shots in order to count had to strike within the circle, aim being taken at the arrow head at the bottom as described above; the shooting at this stage seemed very good, but as I did not stay till the end of it, got no precise data as to the results.



The principle of firing at the feet of a man, represented in this

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practice by the arrow head at the bottom of the target, appears a good one, as a definite object for aim is thereby given, and the tendency of most soldiers to fire too high counteracted. During the intervals while the target was being cleaned up, my friend fell out a recruit, an Alsatian, and told him to explain to me the mechanism of his rifle; the first man not being very bright, another Alsatian was fallen out and explained to me, in French, all about his Mauser rifle, giving the proper names of all the parts, and finishing up with a statement of the number of deal boards it would pierce at — yards, and the number of rounds it would fire in a minute. Another recruit was told to go through the manual and platoon exercise for my benefit, this he did from beginning to end without any further word of command, doing the different motions with a smartness amounting almost to ferocity, and making the proper pauses between each.

I arrived at Berlin on 6th March, and having been fortunate enough to obtain an introduction to an Officer of the Guard Field Artillery, I repaired to his quarters, to which, not only the first time, but on every subsequent occasion, I was never allowed to go but accompanied by a soldier of the Guard, and had to call in at the Guard Room, and ask the N.-C. Officer to detail a man for the purpose. I found my friend most kind and civil, and anxious to show me all the sights of Berlin, except that which I was most anxious to see, viz., the every day drill, and the interior economy of the German Artillery, the strictest orders having, I was told, recently been given not to allow Foreign Officers to see anything of their Artillery. However, on going to my friend's quarters next morning I found that these difficulties had been surmounted and I was permitted to witness the Inspection of Recruits which was then proceeding. I then saw carried out in the Field Artillery the corresponding Inspection to that I had already seen in the Infantry. The Inspecting Officer was a General of Artillery. The recruits were drilled one Battery at a time, and the Inspection was entirely confined to standing gun drill. They were drilled by a Subaltern, while the General, Colonel, &c., moved about among the guns, occasionally looking over the sights.

The drill was carried out with great precision and smartness, and seemed in some respects more practical than our own: that is, more suited for training men to fire with real shell at practice, than for firing blank ammunition on a field day. For one thing, there were three targets out in front of each Battery, and the laying was changed from one to the other every time; another thing, I observed a word of command to prepare to load with common shell or shrapnel as the case might be, so that when the word "load" was given, the loading went on at once, without the fumbling and searching for fuze, hook-borer, and projectile, &c., which I have sometimes seen to occupy a long interval of time between the giving of the word load and the commencement of loading. Every gun has a drill shell of each kind, shrapnel, common and case. The N.-C. Officer in charge of the gun is not one of the numbers that serve it, but superintends generally. The only mechanical duty he performs is to adjust the fuze, which is a fixture in the shell, and fix the percussion nozzle which sets the former in action.

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The mode of laying is peculiar, and consists of one number getting the elevation, while another, at the end of the handspike, gets the line. Time is certainly saved by this arrangement, if both traverser and elevator are agreed as to the object to be aimed at; and as every detail of the German Army bears the impress of deep thought and care in working it out, I have no doubt they have good reasons for laying in this manner. In other respects, the service of the guns was much like our own breech-loading gun drill.

I may here mention that the German Field Artilleryman is trained as a gunner his first year of service, and after that as a driver. The conditions under which the German Artillery Officers succeed in turning peasants into trained soldiers in four months are just the same as those to which I have above ascribed the success of the Infantry Officers in bringing about the same results in their Arm of the Service, and may be summed up as follows, viz., four months continuous drill uninterrupted by fatigues, and absence of Army Form B 91.

The gun which I afterwards had many opportunities of looking at closely, and may also be seen at Shoeburyness, was the Heavy Field Krupp of $8{\cdot}8^{cm} = 3{\cdot}47$ inches calibre. It throws a shrapnel of 8·15 kilos. = 17·96 lbs. and a common shell weighing filled 7·019 kilos. = 15·47 lbs. The projectile is lead coated, and rifling polygrooved. The tangent sight is not inclined.

The axletree seats have indiarubber buffers under them to give ease to the gunner, and a back rail is fitted to the limber for the gunner to rest against and prevent him falling back if he goes to sleep on the march. To assist the gunner to hold on to the axle seat there is a handle fixed to the carriage near the trunnions, and netting on the side next the wheel. The limbers are made of iron or steel, and are fitted on the tray system, opening at the back. The pole is of great length, and projects in rear of the limber, and the wide part close in front and rear of the limber is hollow, a box, in fact, with a lid, apparently used to carry cleaning rags, gun brushes, &c. The pole is so adjusted that with the weight of the swingletree on the end, it is in exact equilibrium. I did not see horses hooked in, but conclude that the obvious clumsiness of this style of draught is compensated for by the ease with which a disabled wheel horse can be removed, and by the greater simplicity of the harness as compared with shaft draft.

Though the trail is fitted with an iron hinge handspike, a wooden one is carried as well with each gun. The rammer is a short implement about 2½ feet long, in shape of a club, the large end of which is used for ramming home the projectile, and the small end, fitting into a socket in connection with the breech apparatus, is used for opening the breech.

I saw the Feldwebel, or Qr.-Mr.-Sergeant, of a Battery, inspecting the gun stores and ammunition of his Battery, and was surprised to see how few small stores there were on charge. This is partly due to simplification of material, but also to keeping in store the various axes, pick and felling, bill hooks, &c., which our Batteries have to bear on charge. There is no attempt at polishing leather or keeping any iron-work bright.

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The strength of a Battery in horses on peace establishment is only 45.

The stables are large and airy, and the whole of the horses of a Battery are contained in one stable; they looked well groomed and cared for, and each one had a blanket, and though unclipped, few had very long coats. They did not look so big in condition as most of our Artillery horses, nor of a stamp so well suited to the work. To my notions they looked rather too leggy and weedy for heavy Field Artillery, but the Germans have not the advantage we possess in having different breeds and classes of horses to apply to the purposes for which they are severally suited. Excepting the Trachena, or old Prussian breed, which are too scarce and valuable for troop purposes, the horses are throughout of a weedy stamp, and though I could have picked out a pair or two of desirable gun leaders, I saw nothing approaching what we consider a powerful and active gun wheeler.

The harness was hung up in stables, and appears reduced to the very minimum of iron and leather that will enable horses to work in draught. The saddle is a simple saddletree, which is placed on a folded blanket on the horse's back, and is reduced to the smallest dimensions; a very broad surcingle made fast with a thong lashing, keeps the whole in its place. I was assured by the Officers that sore backs were very rare, and if this is the case, a saddle which enables stuffing and numnah to be discarded is much to be commended. The stable management seemed excellent, and the German soldier seems very careful and gentle with his horse. The amount of work the horses get in the riding school would alone be sufficient to prevent their carrying much condition. They are kept in the ranks up to any age, and my friend assured me there were horses in the Regiment that had been through the Campaign of 1866.

Riding drill seems to go on all day and a good part of the night, and is the only work the horses are put to during the winter months. I saw several rides, including one of Officers; all Subaltern Officers attend riding drill every day, and at other times of the day have to drill their men, which they seemed to do as well as any Riding-Master (this specialist is unknown in the German Army), and it was amusing to me to see some of these young gentlemen, who were not very brilliant performers round the school themselves, quite alive to the faults of others when it was their turn to stand in the middle with the long whip and command. The horses are brought to a high pitch of training, but I could not see the use of an evolution called the counter-gallop, which consists in cantering round the school on the wrong or outer leg, though it shows the training both of men and horses, that they should be able to make their horses canter on the wrong leg as well as the proper one. I saw that the horses disliked it, and that the most correct application of the "aids" could not always prevent their changing to the inner leg when going round the corners. The Adjutant, whose province it was to drill the trumpeters of his Abtheilung, or Division of four Batteries, kindly invited me to see it; and they being long service men made a very good ride. The Trumpet-Major was in attendance to hear that the calls were correctly blown:

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I then learnt that the bugle is very much used for Brigade drill, and that, by means of it, a Colonel can command and drill his eight Batteries on the move. There are calls for everything, for "Forming Column of Batteries," for "Columns of Abtheilung, &c., &c. There are also calls denoting the nature of the projectile to be used when coming into action.

I must now conclude. Throughout my stay at Berlin, I was received with the greatest kindness and hospitality by all the Officers of my friend's Regiment. I have purposely refrained from mentioning their names, but it will be a pleasure to me if I may be permitted to record my opinion, formed after being with them several days in close intimacy, that there is no more perfect gentleman in the world than the Prussian Officer.

I must apologize for the desultory character of these few notes, but trust that my brother Officers, should they find anything of interest in the matter contained in them, will abstain from criticizing the style.

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NOTES ON ACCOUNTS,

BY

LIEUT.-COL. W. STIRLING, R.A.

Battery Accounts.

The accounts generally of a Battery are comprised under three headings, viz., *Pay List*, *Ledger*, and *Cash*; but are not necessarily limited to this number, for there should, in fact, be a separate account of each Fund or Establishment, the pay of which is drawn in the Battery—for instance, a Native Establishment Account, a Grass Fund Account, &c.; and it is further very desirable to have an account of the nature of a Profit and Loss Account (which in the following example we shall call by that name), in which to enter any slight discrepancy between the double entries, or in which to record disallowances not recoverable in any of the previous accounts, and which must therefore stand over pending adjustment or for further consideration.

A precisely similar form is used for all these accounts, and the checking of them is greatly facilitated by this point being specially attended to; and it follows that as each account is regularly balanced month by month, and such balance duly carried forward, that in the adjustment at the end of the month every item in one column not cancelled by a corresponding entry on the opposite column must find its place in the *Balance-sheet* on one side or the other.

In these forms, as applied to a Balance-sheet, the left column is headed "Liabilities," and the right "Assets." Entries in the former are made as liabilities To . . . . ; and in the latter as assets By . . . . In all the other accounts the left column is headed "Debit" and the right "Credit." In the former all sums received are entered as debtor To . . . . ; in the latter all sums paid as creditor By . . . .

The *Pay List* contains the record of all money transactions between the Commanding Officer and the Government. On the one side is the Pay and Allowances of Officers and men, Savings Bank withdrawals, &c. On the other side, money received from Government in any form on account of the Battery, Savings Bank deposits, Family remittances, or any money received from Officers or men, or from other sources through either the *Ledger* or *Cash Account*, which has to be credited to Government.

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The *Ledger* contains a record of the actual state of the account between the Commanding Officer and each Officer and man in the Battery separately; and these are made up once a month. On one side is entered all Pay issued to the Officer or man, or any deduction to be made from him on account of Clothing, Funds, Stoppages, &c. On the other side all Pay and Allowances drawn in the *Pay List* for each Officer and man, or any sum from whatever source to be credited to him.

The *Cash Account* contains a record of every cash transaction entered at the time, whether it be money received or expended; and the difference between these columns at any time shows the actual cash in hand.

Any other accounts a Commanding Officer may have, such as with a Bank, with his Shoroff, his Native Establishment, his Grass Fund, or any other Battery Fund, are of the same nature as a Ledger Account. On the one side are all sums to be debited, and on the other all those to be credited.

The *Balance Sheet* is not a running account like the above, but a statement of how matters stand at the end of the period to which it refers. It is compiled from the above accounts; and the two columns should always exactly agree, and in this is the check of the work. Where this sheet has been filled up by guess work, it is worse than useless, having occupied much time and being now grossly misleading: but if, on the other hand, the system described be followed, the result will give a valuable and reliable check upon the whole of the accounts for the period.

To Compile a Balance Sheet.

It is necessary to have the Balance-sheet of the previous month, and the accounts above referred to of the month under adjustment. The Balance-sheet of previous month is necessary, in order that any Liability or Asset not disposed of in one of the accounts of the current month may still be entered as a Liability or Asset in this month's Balance-sheet.

The following example, taken from the accounts of a Battery in India, may serve to illustrate the above remarks. The Battery being on service at the time, there was neither Bank or Shoroff employed, and in every way the accounts were reduced to a minimum. The *Pay List* and *Cash Account* are given in a condensed form, but including every sum; and the *Ledgers* give the totals of the vertical columns of the cross-total sheet described in Lieut.-Col. Phipps' excellent pamphlet "Office Manual," and so generally used privately throughout the Corps.

As soon as the month is passed—in this case the month of June—the three principal working accounts of the Battery, viz., the *Pay List, Ledgers, and Cash Accounts* are closed and balanced; and from these, together with the Balance-sheet of the previous month, the Balance-sheet for June and the other accounts for the same month are compiled.

Commencing with the Balance-sheet of the previous month, every

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liability in this sheet must either be cancelled out by appearing in the Credit column of one of the accounts for June, or else the sum will still remain a Liability in the June Balance-sheet. For instance, the sum of R.9 2a. 0p. for Hospital nurse not having been paid, still remains a Liability in June Balance-sheet, and is so at once entered there. The sum R.6 5a. 0p. appears cancelled out in June Pay List, and should be there ticked off. The sum of R.1293 13a. 1p. is credited in Officers' Ledger and must there be ticked off: the next sum R.134 12a. 11p. in the same way is ticked off in the Battery Ledger. The fourth sum, R.117 7a. 7p., does not exactly cancel out in Battery Ledger, where only R.117 7a. 6p. appears, there is one pie therefore that must be credited in Profit and Loss Account to keep the columns evenly balanced. The two sums, R.22 14a. 0p. and R.14 6a. 0p., making R.37 4a. 0p. will be found as one of many items making up the sum of R.2772 10a. 0p. of miscellaneous Commissariat Supplies credited in June Pay List; and so on all down, each sum finding its double entry in the Credit column of one or other of the accounts, and so cancelling out or else still remaining a Liability for June.

Next take the Asset column of May Balance-sheet and proceed in the same way; each sum not debited in one of June accounts will still remain an Asset in June Balance-sheet. The first sum R.1591 11a. 7p. is the first item debited in Cash account, and should there be ticked off. The next sum of R.5 for Fuel allowance for May is debited in June Pay List, and is there to be ticked off. The next two sums appear cancelled out in the Officers' and Battery Ledgers respectively. The sum of R.19 14a. 0p., for Hospital stoppages, taken together with a sum of 15 annas in Credit column of Battery Ledger, making R.20 13a. is debited in Battery Ledger, and so on. The R.80 loan to Coffeewala not having been received in June is still an Asset in that month's Balance-sheet, and so entered. The Gram grinding for November in the same way still remains an Asset in June. Towards the Gram grinding for the other six months, amounting to R.472 1a. 9p., two sums, amounting to R.426 15a. 0p., are debited in the Cash account, leaving the difference of R.45 2a. 9p., which has been disallowed, to be debited in the Grass Fund account. The sum of R.21 10a. 0p., together with R.17 11a. 0p., credited in Pay List, make up R.39 5a. 0p. debited in Battery Ledger.

The examination of the *Pay List* is now proceeded with in the same way. Any sum there debited and not appearing credited in one or other of the subsequent accounts would still remain a Liability, and be so entered in Balance-sheet. The first sum R.3645 1a. 0p. is 2 pie in excess of the sum credited in Officers' Ledger, and this 2 pie must consequently be credited in Profit and Loss account. R.4029 5a. 0p. is 4 pie short of that credited in the Battery Ledger, and this discrepancy must be rectified by 4 pie being debited in Profit and Loss account. The next four sums in Officers' Ledger, Battery Ledger, and Cash account, respectively, cancel out; the Native Establishment pay will be credited to the Native Establishment account. R.55 will be found credited in Officers' Ledger. R.5 for May fuel has already been ticked off, and should be passed over. R.233 14a. 0p. for G.C. pay

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has not been fully credited in Battery Ledger, and the difference, R.1 4a. 6p., is credited in Profit and Loss account. R.12 4a. 0p. is also 2 pie in excess of that credited in Battery Ledger, and this also is transferred as a credit to Profit and Loss account, and so on; the balance at bottom of Debit column not, of course, having been credited anywhere becomes a Liability in the Balance-sheet.

In Credit column in the same the first sum has already been ticked off, and is now passed over; the second sum appears debited in Cash account; the third in Cash account and Officers' Ledger; the fourth in Battery Ledger; the fifth in Cash account; the sixth is made up as follows, viz.:—

R.	A.	P.	
2048	2	0	} Officers' Ledger.
256	4	1	
80	2	8	} Cash account.
25	14	8	
176	9	4	
17	12	8	
119	4	7	
11	4	0	
37	4	0	May Bal. sheet.
R.2772	10	0	

The last item of the above has already been ticked off, and the rest will be found debited in the accounts against them when they should be ticked off.

Thus each account is dealt with, sums ticked off are passed over, all others are cancelled out by a double entry in opposite column or still remain in column on same side in Balance-sheet. On reaching Native Establishment account, every sum required to be entered there from previous accounts will be found, and it only remains to strike a balance between the two columns and carry that balance to the Balance-sheet. The same with Grass Fund and Profit and Loss accounts.

Now as the two columns of May Balance-sheet exactly balanced, and as in each other account the two columns were made to agree by a balancing sum at the bottom, which has been dealt with exactly in the way as any other sum in these accounts; and as every sum on one side has been made to cancel out with a corresponding sum in the opposite column, it follows that the two columns in June Balance-sheet must exactly agree, and hence the check of the work.

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BALANCE-SHEET.

31 May, 18 .

	LIABILITIES.			ASSETS.		
	R.	A.	P.	R.	A.	P.
To Balance on May Pay List	6	5	0	...		
Credits—Officers' Ledger	1,293	13	1	...		
Do. Battery "	134	12	11	...		
February pay for 5 men	117	7	7	...		
Savings Bank withdrawals—Tr. H. ...	121	8	0	...		
Overcharge by tailor	68	0	0	...		
Commissariat—Canteen Rum	166	8	6	...		
Do. Rations—Apothecary B.	22	14	0	...		
Do. Rations	14	6	0	..		
Grass Fund balance	253	14	4	...		
Batta	3	8	0	...		
Native Establishment Account balance	340	5	10	...		
Lascars—compensation, clothing ...	33	0	0	...		
Hospital nurse—malt liquor	9	2	0	...		
Tent repairs—March	31	0	0	...		
Compensation—Puckauly Bhistie ...	35	0	0	...		
Line gear—January, February, March...	97	6	0	...		
Grasscutters— " " " ...	210	3	9	...		
Tailor, completing clothing	277	12	0	...		
By Cash Account—Balance	...			1,591	11	7
Fuel Allowance—May	...			5	0	0
Debts—Officers' Ledger	...			452	7	2
Do. Battery "	...			352	9	0
Hospital Stoppages	...			19	14	0
Sergt. T.—Savings Bank Deposit ...	...			128	6	0
Indian bounty—Gunner L.	...			20	0	0
Ordnance Stores—Revolvers	...			2	8	0
Batta	...			0	12	0
Coffeewala—Loan	...			80	0	0
Gram grinding allowance { November...	...			89	15	6
December ...	...			89	12	6
January ...	...			82	13	6
February ...	...			72	15	6
March ...	...			82	4	6
April ...	...			76	12	6
May ...	...			67	7	3
Regimental necessaries	...			21	10	0
Balance	...			...		
Total ...	R3,236	15	0	R3,236	15	0

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PAY LIST.

June, 188 .

	DEBIT.			CREDIT.		
	R.	A.	P.	R.	A.	P.
To pay and allowances—Officers	3,645	1	0	...		
Do. Men	4,029	5	0	...		
Horse allowance	381	0	0	...		
N.-C. Officers' allowances	42	0	0	....		
Conductor of Stores	15	0	0	...		
Officers' Mess allowance	40	0	0	...		
Native establishment	1,703	10	0	...		
Stationery	55	0	0	...		
Fuel—May	5	0	0	...		
Farriery contract	149	4	0	...		
Women and children	139	8	0	...		
Good conduct pay	233	14	0	...		
Additional pay	12	4	0	...		
Compensation, clothing	9	7	0	...		
Camp colormen	6	0	0	...		
Camp Equipment—May	28	0	0	...		
Savings Bank withdrawals	132	11	0	...		
By due from Comdg. Officer last month ...	...			6	5	0
Cash from Field Treasury Chest ...	...			1,000	0	0
Remittance Transfer Receipts L. ... R1000 0 0						
H. ... 200 0 0						
G. ... 250 0 0						
L.M.A. ... 8 0 0						
Sta. ... 13 2 0						
Mr. B. ... 850 0 0						
Sh. ... 3500 0 0						
Tailor ... 1000 0 0						
S. ... 1000 0 0						
	...			7,821	2	0
Commissariat supplies	...			230	10	0
Do. rum	...			210	9	0
Do. miscellaneous	...			2,772	10	0
Do. Coffeewala, R26; Boots, R7 12 ...	...			33	12	0
Regimental necessaries	...			17	11	0
Family Remittances	...			175	0	0
Effects—N. E. account	...			251	0	0
Savings Bank deposits	...			1,238	14	0
Carbines	...			1	0	0
To due from Comdg. Officer this month ...	3,131	9	0	...		
Total ...	R13,758	9	0	R13,758	9	0

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OFFICERS' LEDGER.

June, 188 .

	DEBIT.	CREDIT.
	R. A. P.	R. A. P.
To Balance...	452 7 2	...
Pay issued	1,555 8 0	...
Remittance Transfer Receipts	1,450 0 0	...
Mess Bills	722 8 0	...
Q.-M.-Sergeant	15 0 0	...
Library and Cricket Club	13 0 0	...
Carbines	1 0 0	...
Stationery—Sta., R42 13; R. T. R., R13 2	55 15 0	...
Sergt. Smith, Kohat	55 0 0	...
Commissariat supplies { R2048 2 0; 256 4 1; 7 12 0 }	2,312 2 1	...
Sponges	5 0 0	...
Miscellaneous	582 6 1	...
Balance...	1,381 2 10	...
By Balance...	...	1,293 13 1
Pay	...	3,645 0 10
Horse allowance	...	381 0 0
Stationery allowance	...	55 0 0
Miscellaneous		682 6 1
Balance	...	2,543 13 2
Total	R8,601 1 2	R8,601 1 2

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BATTERY LEDGER.

June, 188 .

	DEBIT.			CREDITS.		
	R.	A.	P.	R.	A.	P.
To Balance	352	9	0	...		
Pay issued	2,906	12	4	...		
Messing	230	10	0	...		
Hospital Stoppages	20	13	0	...		
Sergeants' Mess subscription	7	5	0	...		
Hair-cutting	28	6	0	...		
Library, R40 2; Cricket Club, R14 6 ...	54	8	0	...		
R. T. R.—L. M. Asylum	8	0	0	...		
Subscription to L. M. Asylum	12	4	0	...		
Family remittance	45	0	0	...		
Savings Bank Deposits...	139	14	4	...		
Families at Campbellpore	270	0	0	...		
Tailor's bill	186	6	6	...		
Boot bill	68	3	0	...		
Rum—May	299	2	6	...		
Cooks and Dhoobies	171	2	0	...		
Regimental necessaries	39	5	0	...		
Sale effects	139	3	0	...		
2/8th Regiment	8	7	0	...		
D/4, R.A.	25	0	0	...		
B/C, R.H.A.	3	8	6	...		
Bounty overpaid	20	0	0	...		
Batta	0	12	0	...		
N. E. Account credit	251	0	3	...		
Balance	31	12	2	...		
By Balance	...			134	12	11
Pay	...			4,029	5	4
Re-engaged pay	...			12	3	10
N.-C. Officers' allowance	...			57	0	0
Family allowance	...			139	8	0
Good conduct pay	...			232	9	6
Batta	...			3	8	0
Messing overcharged	...			0	6	9
Sale effects	...			141	13	0
Savings Bank withdrawal	...			121	8	0
February pay—5 men	...			117	7	6
Compensation—clothing	...			9	6	9
Hospital overcharges	...			0	15	0
Refunded by tailor	...			68	0	0
Balance...	...			251	7	0
Total	R5,319	15	7	R5,319	15	7

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CASH ACCOUNT.

June, 188 .

	DEBIT.			CREDIT.		
	R.	A.	P.	R.	A.	P.
To Cash on 1st June	1,591	11	7	...		
Savings Bank deposits	1,099	0	0	...		
Savings Bank, May—Sergt. T.	128	6	0	...		
Family remittance	130	0	0	...		
Commissary Ordnance—revolvers	2	8	0	...		
Shoeing bullock—April	20	0	0	20	0	0
Cash from field treasury chest	1,000	0	0	...		
Remittance Transfer Receipts { Bank, Bengal	850	0	0	...		
Remittance Transfer Receipts { Shoroff	3,500	0	0	...		
Remittance Transfer Receipts { Nanak Chuna	1,000	0	0	...		
Remittance Transfer Receipts { Conductor of Stores	1,000	0	0	...		
Commissariat supplies—Coffeewala	26	0	0	...		
" " Officers' Mess—November, May	80	2	8	...		
" " " June	25	14	8	...		
" " Bazaar—November, May	176	9	4	...		
" " " June	17	12	8	...		
Commissariat, Khoorum	12	12	0	...		
Gram grinding—January, February, March	208	12	8	...		
" December, April, May	218	2	4	...		
Grasscutters—barley	119	4	7	...		
Sale of effects	2	10	0	...		
Commissariat rations, June—Mr. B.	11	4	0	...		
" Canteen	210	9	0	...		
Lieut. B.—Grass Fund	30	0	0	...		
By Tent repairs, March, R31; May, R28	...			59	0	0
Line gear—January, February, March	...			97	6	0
Grasscutters—barley	...			210	3	9
Charcoal—Khan	...			40	0	0
Grass—Capt. Rennick	...			36	4	0
Receipt Stamps	2	0	0	2	0	0
Tailor	...			277	12	0
Canteen rum—May	...			166	8	6
" June	...			299	2	6
B/C, R.H.A.	...			3	8	6
Donation—Abu L. School	...			14	4	0
Puckauly bullock	...			35	0	0
Compensation, clothing, Lascars	...			33	0	0
9 Lascars—April, May	...			128	0	0
Native Establishment Account—Syces	...			15	15	8
6 months pension—Syces	...			36	0	0
Hospital Establishment—June	...			275	13	0
Officers' Mess Government allowance—June	...			40	0	0
Sergeants' Mess subscription—June	...			7	5	0
" Library—June	...			46	14	0
" " Dr. B.	...			0	4	0
" Cricket Club—June	...			20	6	0
11 Syces, Koorum—June	...			66	0	0
2/8th Regiment	...			9	7	0
Syces, Campbellpore	...			10	0	0
Bhistie Meter, Campbellpore—June	...			9	0	0
Mistry, Campbellpore—June	...			3	9	0
Cooks and Dhoobies	...			171	2	0
Barber	...			28	6	0
Lucern mali—June	...			5	0	0
Tailor	...			186	6	6
Camp colormen	...			6	0	0
Quarter-Master-Sergeant	...			15	0	0
Stationery	...			42	13	0
Sponges	...			5	0	0
Boot bill	...			68	3	0
Native Establishment	...			10	6	2
Farriery contract, R149 3 9; fuel, May, R5	...			154	3	9
Savings Bank withdrawals	...			132	10	0
Sergt. T.—grass	...			24	8	0
Battery pay	...			2,816	11	6
D/4, R.A.	...			25	0	0
Family, Campbellpore	...			360	0	10
Native Establishment	...			1,589	0	7
Extras	...			14	0	0
Officers	...			2,233	0	0
Native Establishment	...			18	0	0
Balance cash	...			1,596	5	3
Total	R11,463	7	6	R11,463	7	6

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NATIVE ESTABLISHMENT ACCOUNT.

June, 188 .

	DEBIT.	CREDIT.
	R. A. P.	R. A. P.
By Balance...	...	340 5 10
Pay List	...	1,703 10 0
To 9 Lascars—April, May	128 0 0	...
N. E. accounts—Syces	15 15 8	...
11 Syces, Koorum	66 0 0	...
Syces, Campbellpore	10 0 0	...
Native Establishment, Campbellpore ...	9 0 0	...
Foorsah	3 9 0	...
Lucerne mali	5 0 0	...
Pulto. Cheydir. Rehnur	10 6 2	...
Cash account	1,589 0 7	...
Cash account for extras	14 0 0	...
3 Syces...	18 0 0	...
Surplus	175 0 5	...
Total ...	R2,043 15 10	R2,043 15 10

GRASS FUND.

June, 188 .

	DEBIT.	CREDIT.
	R. A. P.	R. A. P.
By Balance	...	253 14 4
Lieut. B.	...	30 0 0
To Captain Rennick	36 4 0	...
Sergt. T.	24 8 0	...
Commissariat, R472 1 9—R426 16 ...	45 2 9	...
Surplus	177 15 7	...
Total ...	R283 14 4	R283 14 4

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PROFIT AND LOSS.

June, 188 .

	DEBIT.	CREDIT.
	R. A. P.	R. A. P.
To Pay and allowance—men (*Battery Ledger*)	0 0 4	...
Messing—overcharged (*Battery Ledger*)	0 6 9	...
By February pay, 5 men (*May Balance Sheet*)	...	0 0 1
Pay and allowance, Officers (*Pay List*)	...	0 0 2
Good conduct pay ... (*Pay List*)	...	1 4 6
Re-engaged pay ... (*Pay List*)	...	0 0 2
Compensation ... ... (*Pay List*)	...	0 0 3
Savings Bank withdrawals (*Pay List*)	...	0 1 0
Farriery Contract ... (*Pay List*)	...	0 0 3
Savings Bank deposit (*Battery Ledger*)	...	0 0 4
N. E. accounts... (*Battery Ledger*)	...	0 0 3
Surplus	0 15 11	...
Total ...	R1 7 0	R1 7 0

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BALANCE SHEET.

30 June, 188 .

	LIABILITIES.	ASSETS.
	R. A. P.	R. A. P.
To Balance on June Pay List	3,131 9 0	...
Credits--Officers' Ledger	1,381 2 10	...
" Battery "	31 12 2	...
Hospital nurse	9 2 0	...
Commissariat, Koorum	12 12 0	...
By Cash, 30th June	...	1,596 5 3
Coffeewala—Loan	...	80 0 0
Debts—Officers' Ledger	...	2,543 13 2
" Battery "	...	251 7 0
Charcoal—Khan	...	40 0 0
6 months pension—Syces	...	36 0 0
Hospital Establishment—June... ...	...	275 13 0
Fuel—June	...	5 0 0
Sergt. F., Aboo L. School	...	2 0 0
Gram grinding—November	...	89 15 6
To Native Establishment Account	175 0 5	...
Grass Fund Account	177 15 7	...
Profit and Loss Account	0 15 11	...
Balance	...	...
Total ...	R4,920 5 11	R4,920 5 11

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APPENDIX

ON

KEEPING A CASH ACCOUNT ON THE FOREGOING PROPOSED FORM; WITH EXAMPLES.

BY

MAJOR H. W. L. HIME, R.A.

In compliance with a request from Colonel Stirling, I append some examples of actual accounts kept in the form he has suggested. It is not to be supposed for one moment that this form of Cash Account, or any form of Cash Account, is a perfect safeguard against losing money, or being swindled. But if correctly kept, it will minimise the loss; and by showing how and when money was disbursed, it may lead to the recovery of lost money. Since 1875, when I learnt this form from a professional Accountant, I have had charge of innumerable Batteries, Officers' and Sergeants' Messes, Libraries, Game Funds, and Canteens; and I attribute my never having lost a farthing in any of them almost entirely to my having kept a private account, in the foregoing form, in a small Account Book which I invariably carried away with me when I left a station. Unless the Account is carried off with one's self, the labour expended in keeping it is labour lost; for discrepancies, &c., are, as a general rule, only discovered after one has left. The Official Accounts which remain must of course be kept according to regulation. But the results correspond with one's own. There is one remark I cannot resist making. It is this: the simplest way to cause confusion in accounts and to lose money, is to adopt what is called the "subtraction dodge." You are Secretary to the Officers Mess, and A comes to pay you his Mess Bill of £10. You have previously received £2 for some fund of which he is Hon. Sec.—say the Garrison Geranium Fund—too late to be entered in his Mess Account. In plain words, he owes you £10 and you owe him £2. Instead of entering then and there what actually takes place, *i.e.*, that you receive his £10 and pay him your £2; you imagine you are simplifying matters by entering £8 (the difference between £10 and £2) as received from A for his Mess Bill, receipting the Mess Bill without a thought. So far from simplifying matters, you are actually rendering yourself liable for all sorts of disagreeable results. In the first place, you make a false entry by

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representing A as having only paid £8 towards his Mess Bill, when he has really completely discharged it. In the second place, you are suppressing two actual transactions; his paying you £10, and your paying him £2. What are the consequences, which I have frequently seen take place? The Geranium Fund collapses and is forgotten; you leave the station in one direction, while A is ordered off in another. A year elapses, and a *fracas* takes place over the Mess Accounts. Your Accounts *appear* to be £2 to the bad on the month in question, and you are called upon to explain. You have forgotten the whole set of circumstances, and you cannot do so—you are at the moment, perhaps, endeavouring to bolster up some tottering canteen abroad, and your mind is full of other accounts. A is called upon to pay the balance of his Mess Bill; but having also forgotten the whole transaction, he naturally falls back upon his receipts and refuses to do so. The result is that you have to pay. It may be said, these simple blunders could be easily sifted by good accountants. Very true, no doubt; but the great body of Officers are not good accountants, and we must adopt some form of keeping Accounts that suits our own weakness in this respect. A Cash Book is a history of the financial facts that occur; and if any of these facts be suppressed (with the very best intentions) the Cash Book is worse than useless—it is *misleading*. The Cash Book is the foundation of the whole accounts of the Mess, &c.; and even if the various funds of a Mess get into confusion, they can easily be righted, provided the Cash Book be fully and correctly kept.

Errors, and their Correction.

As long as accounts are kept by fallible men, errors—*bonâ fide*, unintentional errors will occur. Intentional errors, no doubt, are sometimes made; but the proper place for their consideration is not the Proceedings of the Institution, but the Proceedings of a Court Martial. Unintentional errors fall under four heads; errors of sloth, errors of inadvertence, circumstantial errors, and errors of stupidity.

Errors of sloth arise from not entering cash transactions *on the spot*. Delay leads to forgetfulness; forgetfulness to confusion and loss of money. If you happen to recollect on the 5th an entry that ought to have been made on the 3rd, enter it at once: but (for the sake of your successor) enter it as "Omitted on the 3rd."

Errors of inadvertence arise from a man whose mind is preoccupied writing down 8 instead of 6, or carrying over a wrong balance. If you discover the error at once, draw a *very thin* red line through the wrong figures, and write the correct ones above them in red ink. If the error is not discovered at once, it should be corrected in the same manner as an error of stupidity, by *balancing it* on the other side of

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whatever account it may occur in. But never, under any circumstances, *erase* an entry. Banish pen-knives and ink-erasers: they are the bane of an office.

Circumstantial errors arise from circumstances over which you have no control—an error in the Bank Book, a dishonoured cheque. They are treated similarly to errors of stupidity; *i.e,* by *balancing* them, but never by *erasing* them.

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EXAMPLE

Dr. ACCOUNTS OF THE ***REMOUNT ESTABLISHMENT, R.A.,***

DATE.		L. & C. Bank.	Commanding Officer.
Sept., 1877.		£ s. d.	£ s. d.
1st "	Balance Cr. £163 2s. 2d.	163 2 2	...
" "	Pay Corporal, overdrawn in cheque for pay ...	...	0 17 6
10th "	Hopperton, carcass of horse	...	0 17 6
12th "	W. O. Cheque	100 0 0	100 0 0
18th "	Self	...	0 1 0
19th "	R.A. Canteen	...	1 0 9
23rd "	W. O. Cheque	...	100 0 0
25th "	W. O. Cheque	100 0 0	...
29th "	Bombr. P., for Dover telegram	...	0 1 0
" "	Pay Corporal, overdrawn for Pay...	...	0 10 3
	[H. W. L. HIME, Captain, R.A.]		
	Total ...	£363 2 2	£203 7 3

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I.

FOR THE MONTH OF SEPTEMBER, 1877. *Cr.*

DATE.		L. & C. Bank.	Commanding Officer.
Sept., 1877.		£ s. d.	£ s. d.
1st "	Pay, £26 5s. 5d., and bills	52 18 10	...
" "	Canteen Bill	10 10 11	...
3rd "	Fraser, Boot Bill	1 10 6	0 17 6
8th "	Pay £37 19 0		
" "	Washing 1 14 6	56 12 9	...
" "	Bombr. P., Savings Bank 16 19 3		
" "	Canteen	7 18 6	...
12th "	London and County Bank	...	100 0 0
15th "	Pay, £34 1s. 6d., washing, and Paymaster.....	35 6 7	0 17 6
" "	Canteen	7 14 9	...
18th "	Sergt.-Major N., Savings Bank	3 0 0	...
" "	Acting-Bombr. B.	1 2 3	...
" "	Corporal H.	0 2 9	...
" "	Telegram, A.-A.-G., Dover	...	0 1 0
21st "	Barrack damages, N.-C.O.s' Library glass window	...	0 19 9
22nd "	Pay £32 8 5		
" "	Washing 1 15 11	34 5 4	...
" "	Self 0 1 0		
" "	Canteen	7 13 7	...
25th "	L. and C. Bank	...	100 0 0
29th "	Pay £35 3 6½		
" "	Tailor... ... ... 3 15 5	41 15 5	...
" "	Farrier 2 16 5½		
	Total ...	260 12 2	202 15 9
	Balance Cr.	102 10 0	0 11 6
	Total ...	£363 2 2	£203 7 3

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EXAMPLE

Dr. ACCOUNTS OF THE ***R.A. MESS, SHEFFIELD,***

DATE.		S. & R. Bank.	Mess Secretary.
June, 1880.		£ s. d.	£ s. d.
1st "	Balance Cr., £11 13s. 11d. (A)	11 13 11	...
2nd "	Regent's Allowance, Depôt 2nd, R.A.	...	3 2 6
5th "	Captain H. (Mess Bill, May)	...	10 1 9
" "	Arrears, April, Mess, 76th Regiment	...	0 17 9
6th "	Dr. C. (Mess Bill)	...	8 6 0
7th "	Dr. M. (Mess Bill)	...	0 8 10
	Total ...	£11 13 11	£22 16 10

OBSERVATIONS.

A. The Cash balance was all in the Bank, as shown. On the 8th of the month I was ordered off at once by telegram on special duty. The Bank was two miles off, and the Pass Book could not be got before I left. Under ordinary circumstances, the Cash Accounts of the Mess could not have been handed over at all; but as I had kept an account on this form, I was able to hand them over in a few minutes, as shown.

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II.

FOR THE FIRST SEVEN DAYS OF JUNE, 1880. *Cr.*

DATE.		S. & R. Bank.	Mess Secretary.
June 1880.		£ s. d.	£ s. d.
1st "	Servants' Wages (May)	4 15 0	...
" "	Mrs. E. H. (Cook)	2 10 0	...
5th "	Bombr. B., Account. April and May	...	0 15 0
6th "	Dr. C., overpaid Mess Bill	...	0 0 2
	[Handed over to Lieut. A. Brett, 8. 6. 80. H. W. L. HIME, Capt., R.A.]		
	Total ...	7 5 0	0 15 2
	Balance Cr.	4 8 11	22 1 8
	Total ...	£11 13 11	£22 16 10

The Bank Book although correct, is far from being an infallible guide in cases of hurry, such as this. The Bank Book only acknowledges *cheques that have come in*. Thus a Bank Book may show a credit of £100, when it really amounts only to £20—the difference being contained in cheques that have gone out, but have not come in. The only way of checking this (without the foregoing form of accounts) is by comparing the Bank Book with the Cheque Book—a matter which requires care and time in a large account.

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EXAMPLE

Dr. ACCOUNTS OF THE ***R.A. INSTITUTION***

DATE.		L. & C. Bank.	Cox & Co.	Secretary.
March, 1882.		£ s. d.	£ s. d.	£ s. d.
1st "	To Balance	57 10 0	823 4 2	1 17 1
2nd "	Cox & Co.	100 0 0[a]	...	...
" "	Secretary...	3 17 5[b]	...	...
" "	Sundries	...	...	2 7 3
3rd "	"	...	...	1 11 4
4th "	"	...	...	5 16 6
6th "	"	...	...	0 15 5
7th "	"	...	...	7 7 3
" "	Secretary...	7 6 9[c]	...	...
9th "	Sundries	...	...	0 1 0
10th "	"	...	...	1 2 3
11th "	"	...	...	3 17 4
13th "	"	...	...	4 19 6
14th "	"	...	...	5 4 4
15th "	"	...	...	0 13 5
17th "	"	...	...	0 1 0
18th "	Secretary...	2 11 1[d]	...	...
" "	Sundries	...	...	1 16 8
20th "	London & County Bank	...	...	5 0 0[e]
" "	Sundries	...	...	0 8 10
21st "	"	...	...	5 0 6
" "	Secretary...	4 10 0[f]	...	...
22nd "	Sundries	...	...	0 2 0
23rd "	"	...	...	0 4 6
27th "	London & County Bank	...	...	10 0 0[g]
" "	Sundries	...	...	0 15 0
28th "	"	...	...	0 5 6
" "	Secretary...	15 18 9[h]	...	...
29th "	Sundries	...	...	1 16 0
30th "	"	...	...	13 1 10
31st "	London & County Bank	...	...	5 0 0[i]
" "	Sundries	...	...	1 6 5
" "	Various Officers	...	0 16 6	...
	[H. W. L. HIME, Major, R.A.]			
	Total ...	191 14 0	824 0 8	80 10 11

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III.

FOR THE MONTH OF MARCH, 1882. *Cr.*

DATE.	No. of Cheque.		L. & C. Bank.	Cox & Co.	Secretary.
March, 1882.			£ s. d.	£ s. d.	£ s. d.
2nd "	...	By Cox & Co.	...	100 0 0[a]	...
" "	...	Sundries	...	...	0 5 9
" "	...	London & County Bank ...	...	...	3 17 5[b]
3rd "	...	Sundries	...	...	0 2 0
4th "	...	"	...	...	0 10 7
6th "	...	"	...	...	0 4 1
7th "	...	"	...	...	3 14 0
" "	...	London & County Bank ...	...	...	7 6 9[c]
9th "	...	Sundries	...	...	2 5 2
10th "	...	"	...	...	0 10 3
11th "	...	"	...	...	0 11 6
13th "	...	"	...	...	3 13 1
14th "	...	"	...	...	4 12 4
15th "	...	"	...	...	0 12 0
17th "	...	"	...	...	0 9 8
18th "	...	London & County Bank ...	...	...	2 11 1[d]
" "	86	H. Newland	3 5 9	...	...
" "	...	Sundries	...	...	0 12 8
20th "	...	"	...	...	0 3 4
" "	87	Secretary	5 0 0[e]	...	...
" "	88	V. & J. Figgins...	5 12 2	...	...
" "	89	Duhau	8 10 5	...	...
" "	90	Sewell & Crowther	3 1 2	...	...
" "	91	Cattermole...	25 9 4	...	...
" "	92	W. J. Squires	2 19 10	...	...
" "	93	J. Bowles	1 9 0	...	...
" "	94	J. Waites	1 14 7	...	...
" "	95	A. Shepherd	1 17 0	...	...
21st "	...	London & County Bank ...	...	...	4 10 0[f]
" "	...	Sundries	...	...	4 8 7
" "	96	Mr. Needham	...	12 0 0	...
" "	97	Army & Navy Co.-op. S....	...	50 0 0	...
22nd "	...	Sundries	...	...	0 1 9
23rd "	...	"	...	...	0 18 5
24th "	98	Bank of England, for H.M. Stationery Office	...	95 1 8	...
25th "	...	Sundries	...	...	0 17 1
27th "	...	"	...	...	0 17 1
" "	99	Secretary	10 0 0[g]	...	...
28th "	...	London & County Bank ...	...	...	15 18 9[h]
" "	100	Bank of England, for H.M. Stationery Office	...	135 17 7	...
" "	...	Sundries	...	...	0 10 11
29th "	101	Maclure & Macdonald ...	...	18 0 0	...
" "	102	Mr. Sampson	1 12 4	...	...
30th "	...	Sundries	...	...	0 7 4
31st "	...	Secretary	5 0 0[i]	...	...
" "	...	Sundry Ann. Subscriptions	...	3 10 6	...
" "	...	Sundries	...	...	16 15 4
" "	...	Balance (£495 17s. 4d.)...	113 2 5	379 10 11	3 4 0
		Total ...	191 14 0	824 0 8	80 10 11

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The Institution has dealings with two Banks, the "London & County," and Messrs. Cox & Co. The accounts given are taken from the Secretary's Cash Book. The items of the "Sundries" are given in the Sergt.-Major's large Official Cash Book, but nothing would be gained by giving the details of the Sundries here.

MEMO. ON THE FOREGOING FORM OF ACCOUNT BY MR. W. WESTCOTT, CHARTERED ACCOUNTANT.

The London and County Bank, Cox & Co., and the Secretary's Account are to be considered as three pockets, *into* which one paymaster places the monies he receives, and *out* of which he makes his payments.

Any sums received are debited *only* in the column representing the pocket into which it has been placed. Likewise the payments by cheque or out of money in the Secretary's hands are credited *only* into the column representing the pocket out of which the payment has been made.

If money is withdrawn from one pocket to replenish the other, the column representing the one is *credited* with the amount, and the column representing the other is *debited* therewith. The respective sums are lettered off so as to cancel each other.

If a sum be received the whole of which is not paid into one or other of the Banks at the time, it should be entered in the Secretary's column, and so much of it as is paid into one or other of the Banks should be credited to the Secretary's column, and debited to the Bankers, and lettered off.

The amounts appearing in the Account without letters are the pure Receipts and Payments, stripped of the figures necessary to record the transfer of sums from one pocket to the other, and are the amounts *only* which should be posted to the Ledger in the case in which the Cash Account is intended to be posted.

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AMMUNITION

OF THE

1-INCH NORDENFELT MACHINE GUN.

BY

CAPT. W. P. BLANDY, R.A.

It is proposed to give a short history of this ammunition as made in the Royal Laboratory during the past two years.

The first Nordenfelt ammunition issued (generally) to the Service (Navy) was re-packed in the R. L. in small-arm ammunition boxes 30. 8. 79.

The *projectile* was a solid steel bullet with an ogival head, struck with a radius of 1·5 inches, the curve slightly flattened, having radial indents cut or nicked in the base with one cannelure, into which the envelope was choked. An *envelope* of thin brass covered the bullet to the shoulder; it was choked into the cannelure and carefully turned down over the shoulder. The base of the envelope was slightly concave; on firing, the walls of this base portion expanded into the grooves of the gun and took the rifling, while a firm hold was at the same time maintained on the bullet by the base proper being driven into the radial cuts on the base of the bullet. The *lubrication* was pure beeswax round the envelope; no wad of any kind was used. The *powder charge* of 625 grains was pressed into the case, which was of brass, solid drawn. It had a cap chamber having a projection which served as an anvil, and pierced with three fire-holes. The *cup* was of copper, and contained ½ grain of composition.

The above ammunition, as supplied by contract, gave sufficiently satisfactory results, but was expensive, and in the beginning of 1881, ammunition called "practice ammunition" was made in the Royal Laboratory, differing from the above in the following points:—

The bullet was made of the same mixture as was being used for Palliser shell, melted in a cupola, and cast in chills; it was in fact a small Palliser shot.

The *powder charge* was pressed into a pellet, with a pressure of about two tons on each pellet, and inserted in the case, the densest part of the pellet being farthest from the bullet. The pellet was not farther

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pressed when inserted in the *case*. The *case* was varnished inside, as was also the base of the envelope. The radial grooves in the base of the bullet were cut in a more regular form, and not nicked as in the steel bullets. In other respects, this pattern resembled the ammunition above described; a yellow band was painted across the base of the cartridge to distinguish this, the practice, from the Service ammunition. When first tried for accuracy, this ammunition was not found to shoot as well as the Service, the cause was found to be that the base of the envelopes had not been sufficiently pressed out: this was remedied, the ammunition already made being called in and altered. The powder was Messrs. Pigou, Wilks, and Lawrence, No. 8 special.

The muzzle velocity, as appeared from comparative trials in the Royal Laboratory, was from 50 to 100 f.s. greater than that of the contract ammunition. It was now found that the penetrative power of the practice ammunition was equal or nearly equal to that of the Service when fired at steel plates at right angles to the line of fire, but the bullets broke up into two or more pieces; the hole made in the plate was, however, equal in size to that made by an unbroken bullet.

During 1882, various experiments were made in the Royal Laboratory with a view to improve the practice ammunition, so as to make it equal to the steel bullet contract ammunition, and enable it to be used as Service.

The principal points to which attention was directed were:—

(*a*) The improvement of the projectile by using a more suitable iron, or mixture of iron, and by melting such iron in the most suitable way.

(*b*) The improvement of the powder, including the best method of making up, and inserting the charge.

a. Several kinds of iron and mixtures of iron were tried; some of these were melted in a cupola, and some in a crucible. Annealing the bullets was also tried; this was effected by taking about 200 as soon as possible after they were cast and before they had cooled or even lost their *red* heat, and depositing them in a bath of burnt sand; this bath was heated by a slow fire, which returned the bullets to a *blood red* heat; this was kept up for three or four hours, and the bullets were then allowed to cool gradually in the bath. Annealing, although it slightly improved the bullets, was a tedious operation, and was not adopted.

Finally, a suitable iron was selected; it was melted in a crucible and cast in moulds, differently constructed from those previously used. The crushing strength of this iron was about 50 tons to the square inch, and the tensile strength from 12 to 15 tons. Iron bullets were now produced that would remain unbroken after having been fired at a single thick $1\frac{1}{4}$-inch steel plate of rolled Landore steel, or a series of thinner plates of the same material when the angle the line of fire made with the plate was not less than 80°; but at a less angle no iron bullet was found that would stand the cross-breaking strain so well as the steel bullets.

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b. While these trials were going on, the Superintendent Royal Gunpowder Factory produced a suitable powder called M.G[1]., the size of the grain being between a 7 and a 14-mesh sieve: the minimum muzzle velocity allowed being 1420 f.s., and the maximum pressure not exceeding 12 tons to the square inch.

The pellet was made so that the densest part was next the bullet (for this the hydraulic presses in the Royal Laboratory had their arrangement reversed), and after insertion it was further pressed into the case, its length being diminished by $\frac{1}{10}$-inch. The pellet before insertion was enclosed in a thin paper envelope, which had a disc cut out from the portion covering the base, so as to allow the flash from the cap reaching the powder.

The method of first making a pellet was adopted; as pressing down the loose powder (as was done in the contract ammunition) was found to carry away the varnish with which the case was coated, in order to prevent the powder acting injuriously on the metal. After insertion, however, the pellet was somewhat set down as related above, to ensure the space occupied by the powder charge being as uniform as possible.

The effect produced by this ammunition, Mark II. iron, was found to be slightly superior to that of the original steel contract, even against oblique plates: this superiority was, however, found to be due to the superior muzzle velocity given by the better powder; with equal powder, the steel bullets were still found to be superior to the iron, hence it was decided to have a Mark II. iron, and a Mark III. steel ammunition, similar except as regards the bullets, and both *Service.* No more of the ammunition was called practice, and the yellow band was discontinued.

In the beginning of the present year, 1883, a fresh improvement has been introduced by increasing the radius of the head to three inches; with the steel ammunition the penetrative power is increased, and at 1500 yds. range the more pointed head was found to require from 5 to 6 seconds less elevation, so that the trajectory is slightly flatter.

It is not found advisable, however, to increase the radius of head of the iron bullets, as when so increased they are less efficient and break up more than the blunter pointed iron bullets do when fired at a target consisting of two steel plates $\frac{3}{8}$-in. and $\frac{5}{8}$-in. thick respectively, with an interval of five inches between them, the plates being parallel to each other, and at an angle of about 70° with the line of fire. The steel bullets, with heads struck with a radius of three inches, were found sufficiently strong to stand this trial.

A few general remarks on accuracy, muzzle velocity, and penetration will close this paper.

At 300 yards, when fired from a fixed rest on a still day, the average figure of merit is a little over four inches. The averages for the year 1882 were, iron 4·52 and steel 5·14 inches, for all weathers.

The mean muzzle velocity is about 1470 f.s., the powder having from 9 to 1 per cent. of moisture.

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The penetrative power against steel plates is approximately:—

At 100 yards direct	...	...	...	$\frac{14}{16}$	to 1 inch,
200 " "	...	...	...	$\frac{11}{16}$	"
300 " "	...	...	...	$\frac{10}{16}$	"

when the target is placed at right angles to the line of fire. When at an angle of 70° with the line of fire, Mark III. ammunition will penetrate at a range of 100 yards a $\frac{3}{16}$-inch and $\frac{10}{16}$-inch steel plate with an interval of about five inches between them. At 60° a steel plate half an inch thick is penetrated by steel Mark III. ammunition, at a range of 300 yards.

A percentage of all the Nordenfelt 1-inch ammunition, manufactured in the R. L., both iron and steel, is now tried against a plate of $\frac{12}{16}$-inch rolled Landore steel, at a range of 100 yards, and it is very seldom that any bullet fails to penetrate the plate. The weight of the powder charge is 625 grains ± 13 grains; that of the bullet with envelope, 3170 grains ± 50 grains.

A Mark IV. cartridge having a steel bullet with a radius of head of three inches is now made; it has, however, been decided not to alter the pattern of the cast-iron bullets, as with an increased radius of head, these bullets are found to break up more readily than those of the present pattern.

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NOTES

ON THE

ORDNANCE

EXHIBITED IN THE

RUSSIAN NATIONAL EXHIBITION AT MOSCOW,

In 1882.

WITH A BRIEF DESCRIPTION OF SOME OF THE CHIEF GUNS, &c.

BY

CAPTAIN J. C. DALTON, R.A.

(D.-A.-A. & Q.-M.-G., GIBRALTAR.)

HAVING been at Moscow in August, 1882, I was enabled to see some of the newest guns of Russian manufacture, which were on view at the Exhibition, and by the help of the catalogue and from personal observation, I here give a short description of them.

My attention was first drawn to them by Colonel Gonne, the British Military Attaché at St. Petersburg, when I was passing through that city, and he very kindly placed at my disposal some sketches he made of some of them when he visited Moscow a short time previously, which sketches I have found of great use and was able in some cases to supplement. The drawings were made both by him and by me under far from favorable circumstances, and with no means of taking measurements. They are therefore not drawn to scale, and the proportions of the guns can only be estimated by comparing the diagrams with the descriptions. The Russian measurements, which were given in the catalogue, I have converted into English units. I must claim indulgence therefore for the drawings and notes for the reasons above stated.

There can be no doubt of the vast importance to Russia that she can now make her own guns, and be independent, to a great extent, of foreign countries, in case she should be at war with any of them. Hitherto she has made a large use of Krupp's vast manufactory; and her Artillery is greatly composed of Krupp guns. The guns that I saw at Moscow could bear a favorable comparison externally with any I have seen in other countries. They are all breech-loaders.

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Gun Factories, &c.

The principal Gun Factory is the Obukhoff Steel Works near St. Petersburg, in the Village of Alexandrov, on the River Neva. It is thus described in the Russian Official Catalogue of the Exhibition.:—

"The manufactory was founded in 1863, and turns out steel guns, rifle barrels, ammunition, &c. It employs on an average 1260 adults and 150 boys and girls. It possesses for motive power 43 steam engines, each of 1186 h.p., and 20 of 528 h.p. Of furnaces it has 6 puddling, 17 welding, 10 smelting for cast-iron, 249 for steel, 30 for blacksmiths work, and 12 ventilating. In 1880 the foundry turned out 205 guns and mortars (howitzers chiefly, but called mortars) at a cost of over £100,000, and 25,500 rifle barrels at a cost of £10,000. The head of the foundry is appointed by the Admiralty."

Next comes the St. Petersburg Arsenal. "It was commenced in 1844 and completed in 1850. It contains 10 workshops, and prepares bronze guns, carriages, ammunition wagons, proof instruments, range-finders, &c. Average number of workmen, 718; lathes for turning iron and wood, 315; furnaces for casting, &c., 26; blacksmiths furnaces, 68; and 12 steam engines of 295 nominal h.p."

The Briansk Arsenal. "This was founded in 1783, and is situated in the town of Briansk, in the Government of Orlov. The Arsenal makes bronze guns of all sizes, iron carriages both for Field Artillery and for Works, mortar beds, ammunition cases, limbers and other vehicles, iron axles, and stores and laboratory instruments. During the last nine years the Arsenal has produced on an average 150 guns, 630 vehicles, 2457 wheels, and 1136 iron axles annually; and the annual value of the productions during the last nine years averages £6830. Average number of civilian workmen, 686. The driving power of the Arsenal consists of 2 steam engines of 35 h.p. each, one of 30 h.p., and another of 5 h.p., &c., with ample machinery, lathes, &c. It is divided into seven departments, viz., casting, boring, welding, blacksmiths, fitters, joiners and mechanics rooms."

In addition to these there are the machinery works at Wiborg and Bjorneberg in Finland, Gun Foundry at Perm in the Ural Mountains, Arsenal at Kiev, &c.

There were several pieces in the Exhibition that I was not able to get drawings of, but they are all of the type shown in Fig. 2.

The following is a list of the Ordnance exhibited, taken from the Catalogue:—

(1) 11-inch gun for Coast Defence, of steel, strengthened with three rows of rings, on the model of 1877, mounted on a high carriage of latest pattern, with traversing platform, hydraulic compressor, &c., complete. This gun was made in 1880 at the Obukhoff Steel Works.

Weight, including breech-closing gear ...	27 tons 16 cwt. 21 lbs.
Total length	21·85 calibres.
Charge	130 lbs. prismatic powder (density, 1·75)

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Projectiles of steel and cast-iron hardened.

The steel projectile weighs	553·3 lbs.	I. V.[1] 1520 f.s.
Cast iron " "	477 lbs.	" 1500 "
		(With charge of 118·3 lbs.)

Number of grooves	64
System of rifling	Progressive.
Length of sighting line on gun	96·45 inches.

(2) 9-inch steel gun strengthened with two rows of rings; progressive twist; Cemenoff carriage; double-arched compressors. Gun made in Obukhoff Works.

Weight ... ... 14 tons 12 cwt. 7 lbs.

With hardened cast iron projectile of 274½ lbs. the charge is 66½ lbs., and I. V. 1500 f.s.

With ordinary cast iron projectile of 243 lbs. the charge is 57½ lbs.

Weight of	carriage ...	2 tons 1 cwt. 1 qr.
	platform ...	do.

(3) 8-inch steel gun strengthened with one ring. Cemenoff carriage.

Weight of gun		5 tons 11 cwt. 12 lbs.
Charge		32·8 lbs. prismatic powder.
Steel projectile		180 lbs. I. V. 1300 f. s.
Weight of	carriage ...	1 ton 12 cwt. 20 lbs.
	platform ...	1 ton 13 cwt.

(4) 9-inch rifled howitzer of steel, strengthened with rings, on a bed invented by Col. Kokorin, on a traversing platform with compressor, toothed lever arc, &c., made in the Obukhoff Works (Fig. 1).

Weight with breech gear ...		5 ton 6 cwts. 2 qr. 18 lbs.
Projectile		243 lbs.
Maximum charge...		28·8 lbs.
Length of sighting line ...		28 inches.
Weight of	bed	2 tons. } approximate.
	platform	3 tons. }

(5) 8-inch steel howitzer, strengthened with one ring—model of 1877, with lever arc, &c.

Weight of piece	3 tons.
Projectile	172 lbs.
Maximum charge	14½ lbs. I. V. 900 f.s.

This is also from the Obukhoff Foundry; and the workshop in which it was made is capable of turning out 500 guns of different calibres annually.

(6) Siege 24-pr. bronze gun on a high carriage with limber (seated)—model 1877.

Weight of gun	29 cwt.
Charge	3½ lbs.
I. V.	718 f.s.

This gun came from the Arsenal at Briansk.

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[1] I have put I. V. instead of M. V. because the former appears in the original.—*J.C.D.*

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(7) Siege 6-inch gun of steel, strengthened with rings—model of 1877, on high carriage of the 1878 model. Shell, 6-inch with two copper rings.

Weight of gun	3 tons.
Cast iron shell, weight ...	73¼ lbs.; charge, 20 lbs. prismatic powder.
I. V.	1500 f.s.
Steel shell	74 lbs.; " 19 lbs. "
Carriage with wheels ...	30 cwt.

The gun came from Perm Factory, and the carriage from Bjorneberg.

(8) 6-inch bronze howitzer on Cemenoff carriage.

Weight of piece	30½ cwt.
Projectiles of 81 lbs., 67½ lbs., and 64 lbs.	
Weight of charge	From 1·35 lbs. to 5·4 lbs.
I. V.	276 f.s.
Weight of carriage and platform ...	1 ton 13 cwt.

(9) 8-inch gun with reduced weight, in three pieces (Figs. 3, 4 and 5). It screws together, and is mounted on the carriage for the 8-inch howitzer, 5 feet high, with traversing platform. Tools for screwing and unscrewing; gun made at the Obukhoff Works.

Weight with breech-closing gear ...	5 tons 9 cwt. 3¼ qrs.
Weight of projectile	172 lbs.
Weight of charge...	17 lbs. usual powder.
I. V.	1050 f.s.

(10) 9-inch howitzer on same principle, to screw together, mounted on a 9-inch temporary bed (Fig. 6). Tools for screwing and unscrewing. Made at the Obukhoff Works.

Charge	28 lbs. L. G. powder.
Projectile	270 lbs. cast iron.
Weight of piece	5 tons 8 cwt.

(11) Steel (long range) field gun, model 1877, from the Obukhoff Works.

Weight of gun	12 cwt. 7 lbs.
Weight of carriage and wheels	11 cwt. 12 lbs.
Weight of shrapnel shell ...	27½ lbs.
Weight of common " ...	27¼ lbs.
Weight of case shot	27 lbs.
Weight of charge	4 lbs. coarse grained powder.
I. V.	1225 f.s.
Bullets in shrapnel...	340 to 350.
Bursting charge of ditto ...	3·9 ozs.
" " common shell	14½ ozs.

Carriage made at St. Petersburg Arsenal.

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(12) Light field gun for long ranges, of steel, model 1877, on a carriage made at Kiev Arsenal; the gun at Obukhoff.

Weight of	gun	9 cwt.
	carriage and wheels	9 cwt. 2 qrs. 3 lbs.
	charge	About 3 lbs. coarse grained powder.
	common shell ...	15 lbs.
	shrapnel	15 lbs.
	case shot	14 lbs. 12 ozs.
Bursting charge, common ...		·45 lbs.
Bullets in shrapnel		165 to 170.
I. V.		1450 f.s.

(13) Steel field gun, model of 1877, for H. A., mounted on a carriage. Made at Obukhoff Works. (A heavy gun for H. A.)

Weight of	projectile	15 lbs.
	charge...	3·2 lbs.
I. V.		1350 f.s.
Bullets in shrapnel...		165 to 175.

Carriage made at Briansk Arsenal.

(14) 2·5-inch mountain gun, on Baranoff's system, mounted on an iron carriage on the Krell system, with limber, and pack-animal appliances, &c.

Weight of	gun, complete	1 cwt. 2 qrs. 9 lbs.
	carriage and wheels ...	3 cwt. 2 qrs.

(15) A model of a 3-inch B. L. R. mountain gun with carriage and limber.

(16) Mitrailleuse, barrels 0·42-inch calibre, on a high iron carriage with limber.

Weight of piece ... ... 1 cwt.

The only guns, above named, which merit any especial description are, in my opinion, the screw guns, Nos. 9 and 10 in the catalogue. I therefore give a brief notice of them, which I have extracted from a recently published Russian work on Artillery, by N. Pototsky, called "*Outline of Modern Artillery for Cavalry and Infantry.*" I also extract from the same work two diagrams which shew the loading and breech-closing arrangements for heavy guns, as used in the Russian service (Figs. 8 and 9).

8-inch screw gun and 9-inch screw howitzer.

These two pieces are similarly formed, and distinguished merely by their respective lengths and calibres, and by the thickness of their walls (Figs. 3, 4, 5 and 6). Each gun is formed of four separate pieces of steel, viz.:—

An interior tube, a *jacket* consisting of two longitudinal parts, and a *junction nut,* by means of which these two parts are joined together. Each part of the jacket is strengthened with steel rings.

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A screw gun is put together in the following manner :—

The breech part of the jacket, (*A A* Fig. 4) which rests on the brackets (*G*) is transported, together with the latter, to the Battery, and there set in a horizontal position, for which purpose a wooden support (*f*) is keyed under the rear end; the muzzle portion (*B*), which is conveyed in a separate wagon, is supported on skidding in front of the breech portion, and then the nut (*E E*) is run upon it from the front, until it fits over the kerning (*a*), which is near the rear end of the muzzle portion. To this latter is then attached a rope, and, together with the nut, it is hoisted up by tackle to the same level as the breech part.

Previous to this, the parts which come in contact have been carefully cleaned and greased, the thread of the screw is then entered into the hollow cut out for it, and the junction nut (*E E*) first screwed up by hand, and afterwards by means of a lever introduced into the slots (*b b*) which are in the exterior of the nut.

When in this manner, both parts of the jacket are firmly united by the nut (*E E*), then the interior tube is pushed into the breech part, which has been wiped out and greased, as has also the outside surface of the tube.

In order to make the tube (*D D*, Fig. 5) fit completely in its place, a long core with a head (*m n*) is passed along through the tube resting in the rear end of it; on the front end (*k*) of this core there is a screw thread on which is screwed, by means of a key, the nut (*l*); on screwing up the nut, the front end of the core is drawn out from the bore of the gun, and by this means the interior tube is fixed firmly into its place. To take the gun to pieces is the reverse of the former process. First of all, the interior tube is drawn out, for which purpose the core (*m n k*) is employed. Next the junction nut (*E E*) is screwed off, and the muzzle part of the jacket (previously suspended by tackles) is removed from the breech part. The screwing together and taking to pieces of the gun each occupies about 1½ hours, and needs 20 men.

Fig. 7 shews a very long beautifully finished gun that was in the Exhibition, but of which I could not get any description beyond the fact that it is a 14-inch gun, and throws a projectile of about 1100 lb., and is used for Coast Defences, and Sea Service probably.

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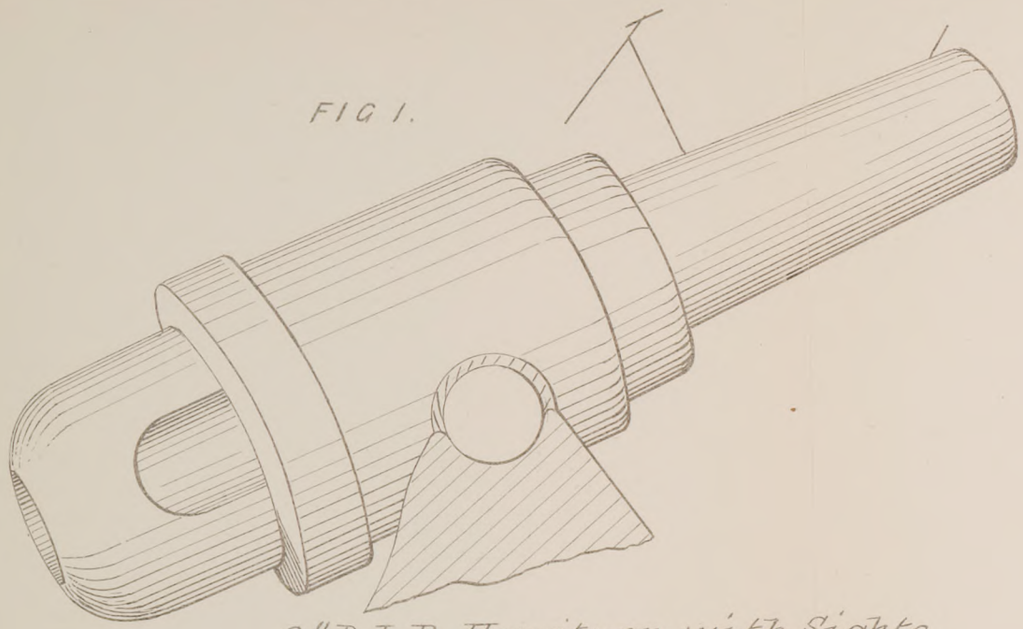
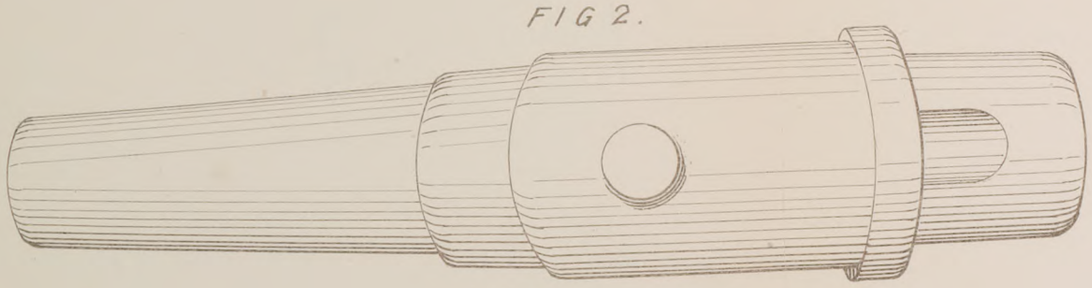
FIG 1.



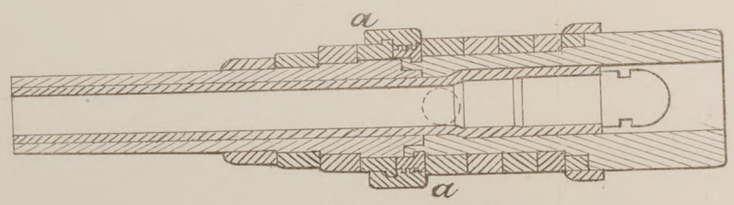
9" B.L.R. Howitzer with Sights.

FIG 2.



9" Steel Gun.

FIG 3.



8" Screw Gun.

FIG 4.

8" Screw Gun.

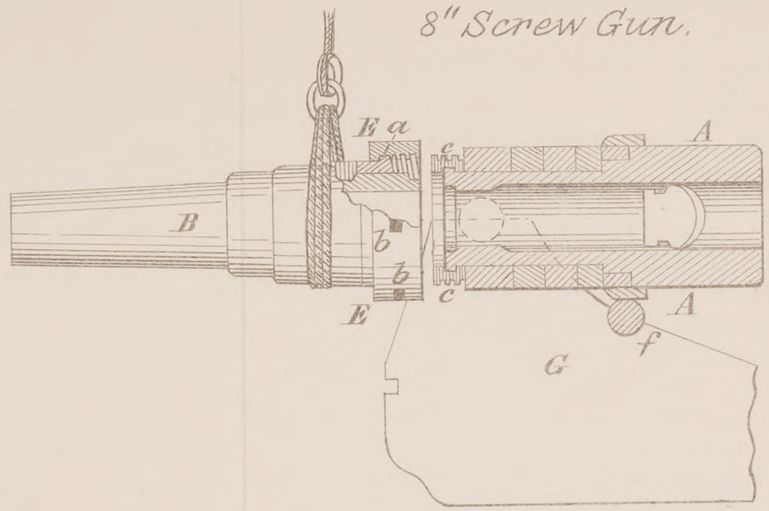


FIG 5.

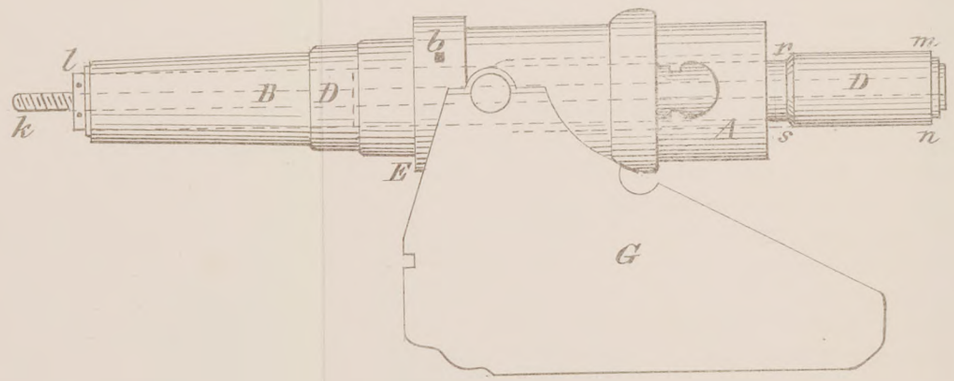
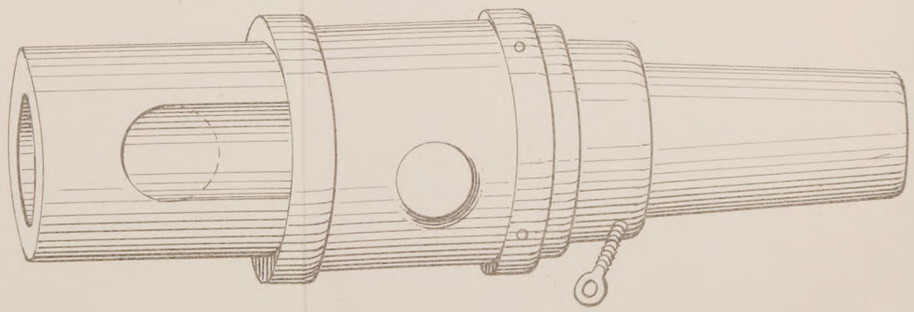


FIG 6.



9" Screw Howitzer.

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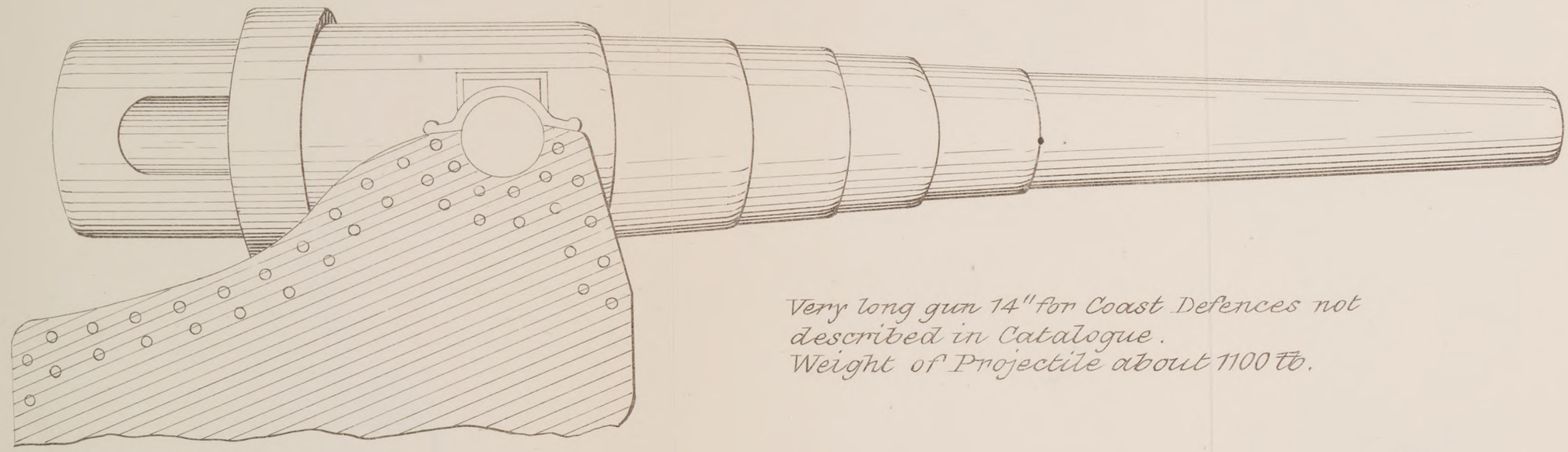
FIG 7.



Very long gun 14" for Coast Defences not described in Catalogue.
Weight of Projectile about 1100 lb.

FIG 8.

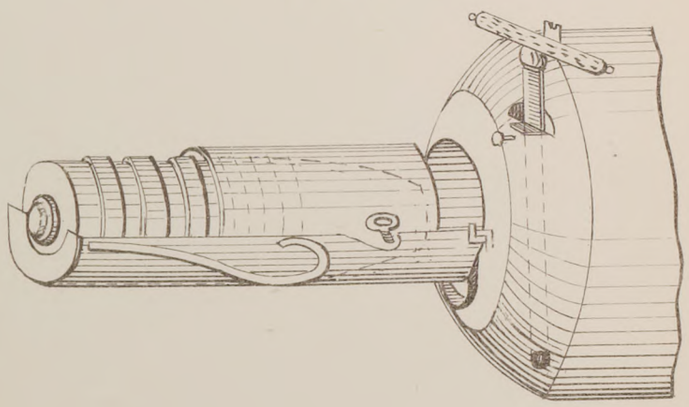
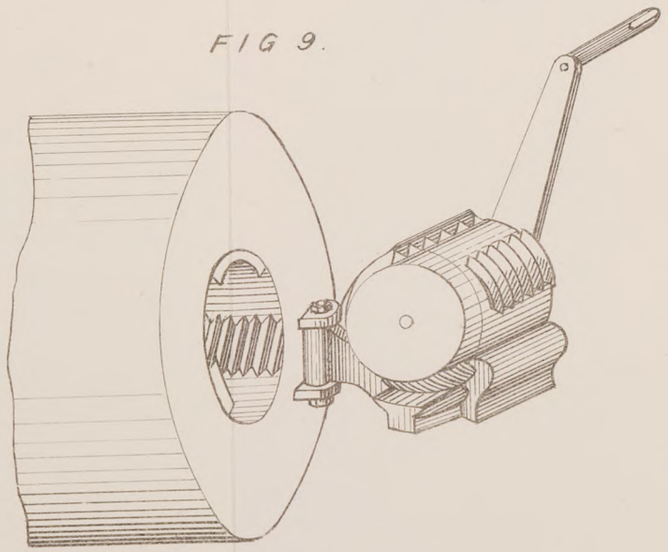


Diagram to shew loading arrangement for heavy guns.

FIG 9.



Side breech closing arrangement called the "Piston bolt" or "French" System.

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THE TRANSIT OF VENUS IN 1882.

BY

CAPT. G. MACKINLAY, R.A.

A SHORT account of the organization and general arrangements of the British Expeditions for observing the Transit of Venus in 1882, may be of interest, as Artillery Officers are occasionally employed on work of this nature.

Without entering into details, it may be stated that, in consequence of the movements of the earth and the planet Venus, the latter can occasionally be seen from parts of the world as a black spot on the surface of the sun, and it appears to travel across, taking some five or six hours to do so. This only occurs at rare intervals—twice in rather more than a century. The last two occasions were in 1874 and 1882, and the next Transit will not be visible till 2004; another will then come after eight years, when there will again be a long interval.

As far as is known, the second Transit of Venus in the 17th century was the first seen by the eye of man. The young English astronomer Horrocks calculated and watched for it, and was rewarded by seeing the planet which generally shines with such brilliancy, plainly visible as a black spot on the surface of the sun; observations of the phenomenon were attempted.

At the beginning of last century, attention was directed to the Transits of Venus expected to occur in 1761 and 1769 by various persons, chiefly perhaps by Halley, the British Astronomer Royal; he pointed out for the benefit of any, who should live till the time of those Transits, that accurate observation of the time of apparent touch or "contact" of the edges of the sun and the planet from some of the different parts of the earth's surface, from which it would be seen, afforded a trustworthy method[1] of finding the distance of the sun from the earth; and if this distance is once found, a number of others will follow at once, since the *relative* distances of all the planets from each other, and from the sun, have long been known—like a map without a scale.

Accordingly on both occasions, not only the British Government but also many Foreign ones sent numerous expeditions to various parts of the world favourably situated for obtaining good results. Many expeditions were sent out, as bad weather was to be apprehended at

[1] The difference of the times of contact at two stations afforded an excellent means of measuring the small angle (only a few seconds of arc) subtended at the sun by the known distances between the two stations on the earth. Hence the distance of the earth from the sun could be found.

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some, and it was thought best to have several observations to depend upon instead of only a few.

As often happens, when the real observations were carried out, unexpected difficulties were found to exist, these were chiefly caused by an atmosphere which surrounds the planet, and also by the brightness of the sun, which gave the appearance of a kind of adhesion or drawing out of the edge of the planet at internal contact, and rendered the exact time rather uncertain; the slow and lingering nature of the movement also added to the difficulty.

The observers were better prepared at the second Transit in the 18th century, and after a good deal of discussion over the results of the observations, the distance of the sun was calculated to be about 95,000,000 miles, and this was the distance assumed for many years.

During this century, however, other methods of finding the distance of the earth from the sun have been discovered, none of them alone quite as good as that afforded by a Transit of Venus, but as they can frequently be applied they have furnished a mass of reliable data from which to calculate, and, consequently, they are more valuable than the results of Transits of Venus which occur but seldom.

The chief of these methods may be classed as under:—

1. Trigonometrical. 2. Physical. 3. Dynamical.

These different methods have not as yet given very accordant results, but they all agree in making the distance less than the 95,000,000 miles, which was deduced from the Transit of Venus of last century.

An example of the trigonometrical method is afforded by finding the distance of Mars when nearest to us. Mars was observed, and its position and angular distance from certain stars carefully found at a certain time, and after the lapse of several hours its distance from these stars was again measured, when it was found to be different, because the rotation of the earth had carried the observer to a different place: the displacement was inappreciable with regard to the almost infinitely distant stars, but it told upon the position of the planet. Hence the distance of Mars was found. One of the distances in the solar system being thus obtained, the others also followed.

The physical method is illustrated by the velocity of light. The satellites of the planet Jupiter revolve round it, and are periodically hidden, or occulted as it is termed. When however Jupiter is at its greatest distance from us these occultations take place some sixteen minutes later than when it is in its nearest position. This apparent irregularity was at one time difficult of explanation, until it was considered that in one case the light announcing the occultation travels a much greater distance in coming to us than in the other—the difference being the diameter of the earth's orbit, or twice the distance of the earth from the sun; it was concluded that the occultations always takes place at nearly regular intervals, but that it takes 16 minutes longer for us to see them in one case than in the other. Experiments on the earth's surface to find the velocity of light, agree well with a distance of the sun of over 90,000,000 miles by this plan.

The dynamical method is illustrated by the perturbations of the motion of the moon; strange as it may seem, the motion of the moon

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is not yet fully or satisfactorily determined, its mean distance is well known, and hence if its small perturbations are known the distance of the perturbing force, *i.e.*, of the sun, can also be found by its varying attraction as its distance alters. This method will probably give the most trustworthy results after many years of repeated observations, but it requires time.

It will thus be seen that the results of the late Transit were not so important as those of last century, because the problem has already been approximately solved by this method before; and other ways of arriving at the same result have been discovered; but though it lacked the charm of novelty, it was not to be neglected, as Transits of Venus occur so seldom, interest in scientific matters has greatly developed, and opportunities for travel have so enormously increased, that all the Governments of the civilised world again sent out a great many expeditions in 1882.

The distance[1] deduced from the observations of the 1874 Transit of Venus is 93,300,000 miles, that given by the 1882 expeditions has not yet been worked out.

With regard to the preliminary arrangement for the expeditions of 1882, it was evident from previous experience that each observer should, as far as possible, record the time of the appearance of the *same* phenomenon.

With this object in view, all the observers, whatever their previous training, were assembled at Oxford, during the early part of the summer of 1882, under the direction of E. J. Stone, Esq., F.R.S., the executive Member of the Committee of the Royal Society deputed to carry out the British Expeditions. Colonial observers were also represented at Oxford. A printed pamphlet of instructions, based on the experience gained from the 1874 expeditions and those of last century, was carefully explained and gone into by Mr. Stone with each observer. The telescopes to be used were all of about the same diameter of object glass (6 inches); each was to employ about the same magnifying power and also about the same degree of darkening the bright image of the sun. These matters were all arranged personally.

For practice, and also for comparing the method of observation of observers going to different parts of the world, a model of the Sun and Venus, the latter moving at the apparent rate the real planet would have, was arranged at a distance of some 200 yards from three telescopes, and the times of contacts of the edges of the discs, as estimated by different observers, was compared. This was done again and again on repeated days with very fairly accordant results.

Practice with the model was of use, as it afforded an example of the rate of movement of the planet over the disc of the sun; but many experts thought that much use of it might be misleading, as the effects of the atmosphere of Venus and of the brightness of the sun could not be copied in the model. In fact, many said that the results of the

[1] The ratio between the distance of the Sun and the longest practically obtainable base line on the Earth surface—such as the distance between Jamaica and Australia—is about the same as that which would exist between a base line of 3 inches and a range of 1600 yards. Hence the difficulty of obtaining a very accurate result is apparent.

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1874 expeditions were vitiated by a too servile use of model practice beforehand, and that several observers had employed themselves at the actual Transit, in trying to trace something, which resembled that which they had seen in the model, instead of faithfully recording what really happened.

The large hall of the Radcliffe Observatory, Oxford, of which Mr. Stone is the head, furnished a very convenient depôt for storing packed boxes; the ample grounds attached to the observatory gave room for the erection of huts, and the putting together and adjustment of instruments, for the purpose of seeing if everything was in working order. The permanent observatory and the staff of assistants also afforded great help in verifying observations, &c.

The observing parties were divided into three main geographical groups. The first were to proceed to the neighbourhood of the Cape of Good Hope and Madagascar, where the beginning of the Transit would be witnessed late in the afternoon, and the sun would set with the planet apparently on its face. The second were destined for the West Indies and Bermuda, where the Transit would begin in the morning and end in the afternoon. The third had the longest journey to make,—to New Zealand and Australia, where the sun would rise with the planet on its surface, soon, however, to pass away from it.

The difference between the time of contact at ingress at the Cape and at the West Indies, afforded a means of measuring the angle at the sun subtended by the known distance between these two places on the surface of the earth, hence the distance of the sun could be deduced; and the difference between the time of contact at egress at a station in the West Indies and one in Australia, gave data for a fresh and independent determination of the same great distance.

Each group was composed of three or four stations or expeditions at considerable distances from each other, so as to avoid the risk of all of them failing from the same cloudy weather; for instance, the second group had stations at Jamaica, Barbados, and Bermuda. The permanent colonial observatories at the Cape and at Melbourne gave their assistance to the other groups.

The members of each expedition consisted of two observers, who were to make independent observations of the Transit with similar telescopes, and a soldier of the Royal Marine Artillery was detailed, as assistant, to help in packing and setting up the instruments. Each complete expedition came successively to Oxford, and remained for about a month, practising with the large telescopes and testing the smaller instruments for finding the time and the latitude; various alterations were then found to be necessary, and time was given for their execution. Two parties were generally at Oxford together, but as they arrived at different times confusion was avoided, and each member had the opportunity of meeting and comparing notes with other observers proceeding to different parts of the world.

The expeditions, going farthest, which had to start soonest were the first to practice at Oxford; when they had finished, all their things were packed up, each package was numbered, painted with the distinguishing mark of the party, carefully labelled with printed

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labels, a list taken of the contents of each box, and the whole were stored away until they were wanted.

The instruments for each expedition consisted of two 6-inch telescopes equatorially mounted, so as to follow the movement of the sun conveniently. Each of these, with all its mountings, occupied some half a dozen large boxes, and the hut with its flooring made up more than that number of large packages. Most of the expeditions found the time and also the latitude by means of an alt-azimuth instrument, mounted on a pillar in a hut. But the Jamaica party took out Lord Crawford's beautiful reversing transit[1] instrument, which very readily gives the time, and also by shifting the telescope into an auxiliary set of Ys the latitude can be found by the very accurate method of the time of a star crossing the prime vertical. A small alt-azimuth was also taken to Jamaica.

One or two astronomical clocks and several chronometers were taken by each party. Some of the instruments were the property of the Government, while others were lent.

To go a little into the details of one of the expeditions which may serve as a specimen of all:—The Jamaica party consisted of Ralph Copeland, Esq., Ph.D., Astronomer to Lord Crawford, as head, the writer of this article as second observer,[2] and Bombardier A. M'Culloch, Royal Marine Artillery, who acted as orderly, storeman, &c. Before starting, much local information, as to climate and the relative advantages of various sites for an observing station in Jamaica was obtained from many Officers and others; an official handbook of the island and the best map obtainable were carefully studied. Passages were secured in the Royal Mail Steamer leaving Southampton on the 17th October, and a few days before that time the boxes and packages were sent off. One of the observers superintended their despatch from Oxford, and also saw them carefully put on board at Southampton; this ensured nothing being left behind, and also extra care was given to the handling of the boxes containing the more delicate instruments. The Officers of the Royal Mail gave every assistance. The same ship also took out a similar party to Barbados, in which Lieut. J. H. Thomson, R.A., was an observer.[3]

During the voyage the beautiful comet, which rose two or three hours before the sun, was a most brilliant object as lower latitudes were reached, especially during two or three nights when there was no moon to diminish its brilliancy. The planet Venus naturally also excited interest; it could be seen as a bright speck high up in the heavens nearly all day long with the naked eye, but when the sun had set and darkness came on, the planet (now at its brightest and in a clear

[1] The Transit instrument is used for finding the time by the passage or Transit of a star over the meridian. The transit of Venus was across the face of the sun, and was observed with equatorial telescopes.

[2] The Astronomer Royal had kindly given permission to practise at the Royal Observatory, Greenwich, with one of the small Government Transit instruments; this he afterwards lent for employment in the preparatory training at the R.A. Observatory, Woolwich, where all arrangements for assistance were most readily made by the Secretary, R.A. Institution.

[3] Captains Morris and Darwin of the Royal Engineers were the members of the Expedition to Brisbane, Australia. Colonel Tupman, late R.M.A., and two Naval Officers proceeded to other stations.

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atmosphere) shone out with such brilliancy, that a very decided path of light was reflected on to the water, and just before setting it presented the appearance of a bright lighthouse, near at hand.

After about a fortnight Barbados was reached, where most of the passengers travelling to various parts of the West Indies and South America left the ship. Here also the Barbados Transit of Venus party went ashore with all their gear; and in the hurry of unloading, one of the Jamaica instruments was being unshipped, but thanks to a good look-out and plenty of labels the mistake was found out at once. Arrived at Kingston, Jamaica, some five days later, the first thing to be done was the selection of a site for an observing station. The requisites of such a place were, first, the probability of a clear unclouded sky, secondly, it should be tolerably healthy, as previous experience had shewn that the observers' health must be attended to;—In the 1874 Transit of Venus Expedition to the Mauritius, the Members of Lord Crawford's Expedition, and also those of a German one suffered severely from fever, and several were incapacitated from observing for many days. Thirdly, as the time and funds at disposal were limited, it would be well to choose an easily accessible place, more particularly as risk of damage to the delicate instruments would be lessened; and lastly, a quiet retired spot, where the observers would be free from interruption, was manifestly desirable.

The Island of Jamaica well bears out the description which Columbus gave of it to his Queen—it is like a crumpled piece of paper, so irregular and jagged are its mountainous outlines; towards the coast, however, there are some alluvial plains and gentle slopes washed down by the action of water from above. The official handbook, stating that the rainfall is decidedly much less on the southern than on the northern side, made it evident that some place not far from Kingston must be selected: a visit was early made to the top of a neighbouring steep hill named Wareka, some 1400 feet above the sea, and a spur from the higher range, as it was thought that this might offer a good position, as there is an extended view of the heavens; it is a quiet spot, and on account of the elevation, it is a little cooler than the lowland, while it is comparatively free from the clouds which so often gather round the higher mountains. But the difficulties of the ascent for the 47 large packages and boxes of the expedition (many of which would have had to be unpacked at the bottom of the hill, and carried up piecemeal by hand), and the large amount of tropical bush and undergrowth necessary to be removed, precluded the idea of making this hill-top the chosen place. The visit, however, afforded an opportunity of a good view of the surrounding country, and it soon became evident that the cool mountains must be avoided, from the difficulties of transport and for fear of clouds, as it was often noticed that the day broke with the mountain-tops showing their ragged outlines clear and sharp against a cloudless sky, but as the day wore on fleecy clouds gradually accumulated round their summits and on their sides, while the atmosphere in the plain near the sea remained undimmed.

In the lowland at and near Kingston the hotels were not found to

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be convenient, and it would have been difficult, if not impossible, to have secured the necessary quietness: but Up Park Camp, on gently rising ground some 120 feet above the sea appeared to be the most suitable spot,[1] and it was consequently selected. The Officers of the 2nd West India Regiment, then stationed at the Camp, most hospitably made the observers honorary members of their mess, and gave them two large cool rooms in the Officers quarters for their use; while a quiet and almost entirely enclosed corner of the extensive lines was assigned for the erection of the huts for the telescopes. This position had the advantage of being within 2½ miles of the landing wharf at Kingston, from which there was a good road all the way, and it was only about the same distance from Lord Rodney's statue, of which the longitude was found a few years ago, with astronomical accuracy, by Captain Green, United States Navy, and from which the longitude of the Transit of Venus station was to be measured.

The site selected, the next thing was to prepare the ground, and soon a party of negro soldiers of the 2nd West India Regiment were cutting away the weeds and grass with cutlasses, and fencing round the huts. Permission having been obtained for all the boxes to pass through the Customs free of duty, Colonel Clayton, C. R. E., kindly arranged[2] with the government contractor to bring up the packages without delay, and at the same rates as government stores for the troops, &c., and in the course of two or three days all were safely delivered, though some of the larger ones were only brought up with difficulty.

All the packages were deposited in a heap in the middle of the intended observatory camp, while a little way to the north a tent was pitched; this served as an occasional protection from the sun while erecting the huts and instruments, and afterwards it became a kind of store and a place for cleaning and keeping the lamps necessary for night work. To the east and to the west of the centre were the huts for the large telescopes, which thus had an uninterrupted view, while to the south was the hut with the Transit instrument and the standard clock. The whole camp was thus roughly in the shape of a square with a diagonal north and south. Near[3] the centre (when the boxes had all been unpacked and the empties stored under a neighbouring barrack building), was placed a concrete foundation for the stand of the alt-azimuth instrument.

One of the large telescopes was a fine modern one by Cooke, mounted on a very large and steady cast iron pillar which rested on a concrete foundation. It was contained in an ingenious kind of hut-tent (Fig. 1); wooden sole plates (placed in an octagonal form flush with the levelled surface of the ground) carried a circular racer, on this rested several small iron rollers or trucks attached to the iron gas-pipe framework of the hut, which could thus be easily rotated. The hut

[1] The various bugle calls and tattoo rendered the eye and ear method of observation of stars somewhat difficult at times, but as the preliminary training at the R.A.I. Observatory, Woolwich, had necessarily been under similar conditions, this hindrance was but little felt.

[2] It was a great advantage to have this and other work carried out under efficient local control, as strangers are frequently imposed upon and subjected to needless and vexatious delays.

[3] If the alt-azimuth foundation had been exactly in the centre, it would probably have caused a fall to someone (possibly with a chronometer in his hand) when walking in the dark from one hut to another.

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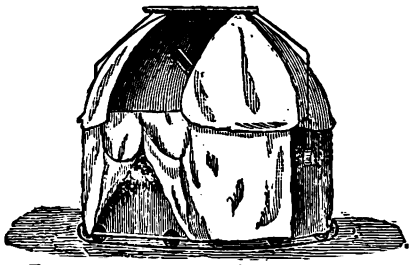
was covered with canvas, its lower part was cylindrical and contained the curtained entrance, the roof was dome-shaped, with a large shutter capable of being pushed back by aid of counterweights on each side, and giving a large opening like a huge mouth.

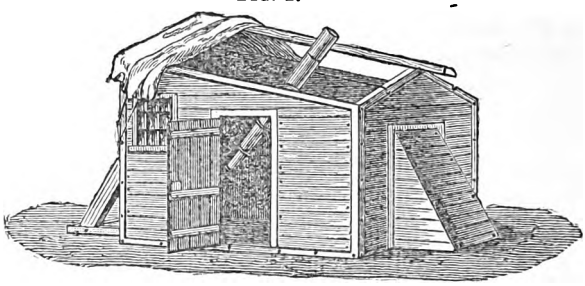
Huts for 6-inch Equatorial Telescopes.

FIG. 1.



ROTATING HUT-TENT—SHUTTER OPEN.

FIG. 2.



RECTANGULAR WOODEN HUT—ROOF OPEN, TARPAULIN TIED BACK.

The other telescope was one of historical importance, being that with which the late Admiral Smyth, R.N., F.R.S., &c., made his observations at Bedford; it is thoroughly described with numerous diagrams in his well-known work, "The Celestial Cycle," and it was taken by Capt. Orde Browne (*late* R.A.), for the Transit of Venus observations in 1874, to the Mocattam Hills, near Cairo. It was mounted in what is termed the "English" manner, with a long polar axis resting on strong frame supports near each end of a large rectangular wooden hut (Fig. 2). This is an old-fashioned arrangement, and it is by no means steady when there is a wind: fortunately the 6th December was a very calm day.

The roof of this hut was covered with a large tarpaulin, supported by a ridge pole, which gave the sides of the roof the necessary slope for carrying off rain water: when the telescope was used one end and the sides of the tarpaulin were unfastened and it was pulled back and secured; one end of the ridge pole could also be pushed out of the way, the other was fixed to a pin. Some few minutes were occupied in opening and in closing up the roof again.

The reversing Transit instrument was mounted on a very carefully made concrete pillar, to obtain the requisite steadiness, and the octagonal wooden hut which contained it was able to revolve on a circular racer, and the roof opened to allow of the telescope being

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used. The standard clock in this hut was attached to a large tripod frame, whose feet rested on concrete foundations; the flooring being kept clear so as to avoid vibration being given to the telescope or to the clock. A similar clock was similarly mounted in the large rectangular wooden hut.

Although great help was given by three men of the Royal Engineers, stationed at the camp for a few days, and also by a party of the 2nd West India Regiment, a good deal of exposure to the sun was unavoidable in putting up and adjusting the instruments, and all three members of the expedition began to suffer: a short visit to Newcastle (the hill station for European troops) gave the needed rest and drove away the symptoms of fever. Here the Officers, Royal Scots and Royal Artillery, were most hospitable.

The huts were all erected and the instruments adjusted just before the arrival of the following bi-monthly mail from England, which brought out Maxwell Hall, Esq., an astronomer, and a resident at Montego Bay, in the western part of the island, where he has an observatory. During the two days of his stay in Kingston, an opportunity was given for observing stars with him,—this was necessary for personal equation, as the expedition were directed to assist him in obtaining the longitude of his observatory from Lord Rodney's statue.

Considerable interest in the object of the expedition was shewn by residents in Jamaica, but soon all visitors had to be refused till after the Transit, though there still remained rather more than a fortnight.

Regular systematic observing was then carried on nightly for about three weeks, the weather being admirable, as there was hardly a night during that time when no observations could be made, although sometimes there was tedious waiting: generally the sky cleared up, if not already cloudless, soon after sunset, and the temperature at night out of doors, or in the open huts, was all that could be wished for.

Observations were made each night for finding the time with accuracy from the stars, and the results worked out by day: the clocks were regulated and their errors and rates carefully noted to see that they went uniformly.

The longitude required care and arrangement; one observer taking post at Lord Rodney's statue, found the time with the portable alt-azimuth, while the other obtained the local time at Up Park Camp with the Transit instrument. At the same time Mr. Hall found his local time at Montego Bay, and exchanged a long series of electric time signals with the observer at Rodney's statue (some 70 miles distant: the difference of local time between these stations was thus found and hence the difference of longitude. Chronometers were carried from Up Park Camp to Lord Rodney's statue and back, and carefully compared with the local time at each place. This was done on three nights, and on two of these Montego Bay was also included. It was tiring work, as repeated observations had to be made, and it took several hours on each night.

The latitude of Up Park Camp station was found by three nights observations of the times of stars crossing the prime vertical.

There was practice by day with the large telescopes on the sun, and

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the clock-driving gears were regulated to enable them to follow its motion. Owing to the magnifying power employed (about 150) only about one-sixth part of the sun's circumference could be seen in the field of the telescope; it was therefore essential that the proper part of the limb of the sun should be watched, so that the first external contact of the planet might not be missed, as it cannot be seen as it approaches the sun. The inversion of the image and the reflection from the solar eye-piece made this rather puzzling, but by remembering that Venus overtakes the sun, the proper spot was easily found by subtracting the difference between the tabulated declination of the southern limb of the sun and of the planet from the observed declination of the southern limb of the sun, and then watching that part of the following limb which had this declination.

Until a day or two before the Transit (when the planet came into the brightest part of the heavens near the sun), Venus could generally be seen by the naked eye in an unclouded sky all day long (or at least from an early hour in the morning) when search was made in the proper direction, and in the telescope it presented a beautiful appearance, like a finely-crescented moon waning gradually day by day, but increasing in diameter and getting more and more in the direction of the sun.

The days before and after the Transit of Venus were many of them cloudy, but the 6th December was bright and clear at Up Park Camp. After rising early on that morning, to get a last check on the clock from the stars before daybreak, comparisons of the other clock and chronometers were made with the standard, and soon after 8 a.m. the necessary preparations of uncovering the huts, pointing the telescopes, and adjusting the eye pieces, &c., were made, and the proper part of the limb of the sun was intently watched while the count was taken up from the clock. On that day no one was allowed in the observatory enclosure during the time of the Transit besides the observers and the bombardier: an orderly patrolled outside to keep any one from making a noise in the neighbourhood, and all bugle sounds were stopped in the Lines.

SUCCESSIVE TELESCOPIC APPEARANCE OF THE TRANSIT OF VENUS AT INGRESS.

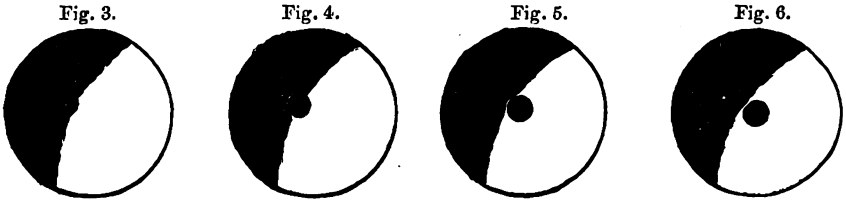

Fig. 3. Just after external contact at ingress.
Fig. 4. About 7 minutes later: faint halo round a great portion of external part of Venus.
Fig. 5. About 7 minutes later than Fig. 4: halo all round the external part of Venus.
Fig. 6. Just before internal contact at ingress.

The complete circles represent the field of the telescope: the bright part in each is a portion of the sun considerably magnified: the dark part represents the heavens: the notches and small black discs are the planet Venus.

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Presently, among the quivering ripples which constantly appeared on the limb of the sun, there gradually came a firm dark rounded hollow, which, unlike the ripples, did not quiver, but steadily increased in size (*see* Fig. 3). This was the planet coming on to the face of the sun, and the time of the first appearance of this was carefully noted as "external contact at ingress." The hollow or notch in the edge of the sun became deeper and deeper, and in a few minutes the outline of the whole planet was given by a halo of light (*see* Figs. 4 and 5) round that part which was not yet on the sun: this halo was brighter at one spot than at others, and is supposed to be caused by the rays of light from the sun falling on to an atmosphere surrounding the planet. It took about 20 minutes for the whole planet to cross over the edge of the sun, but just before this happened careful observing had to be made. As the edges of the sun and planet separated (*see* Fig. 6) there seemed to be a kind of gradual shading between them, but this was not what was searched for. Slowly, very slowly, did the bright parts on the sun behind the planet close together after it, and the time when it was estimated that there was first a narrow band of light permanently as bright as the rest of the sun, was looked for and recorded as "internal contact at ingress." It was here that the atmosphere caused the previously experienced difficulty, making the recorded time later than what may be called the geometrical contact of the two circles. On went the planet looking like a large blot of ink on a bright surface, its edge well defined and slightly purple, its central part intensely black. Measurements of cusps during the passage over the limb of the sun, and of distances of centres of the planet and the sun afterwards were made by some observers but not by all, as they are not so trustworthy as simple "contacts."

Little could be done during the six hours that elapsed before the "contacts" at egress; the planet was of course carefully watched, but no sign of a satellite could be found:—One of the observers noted the times of passage of the limbs of the sun and of the planet over the meridian in the Transit instrument.

Towards the end of the Transit a few clouds came drifting across the sky from the eastward, but they soon passed away, and the sun was unclouded at the egress "contacts," when nearly the same phenomena as those witnessed at ingress were repeated in reverse order; very slowly did Venus move away from the sun, as if loth to go, but at last the rounded notch was seen getting smaller and smaller, and in a few seconds more the ripples at the edge of the sun flowed on undisturbed where the planet had been, and the Transit of Venus was over, never again to be witnessed by the eye of any now living.

Each observer was independent and wrote down his results before speaking to the other, and thus unbiassed testimony was obtained. A short telegram was sent at once to Mr. Stone and a short report by the next mail. The whole of the observations with a duplicate copy were afterwards lodged with the Treasury officer, and the original and copy were sent home by different mails to lessen the risk of loss of both.

Just after the Transit came a comparison of the chronometers with the standard clock, and after dark the standard clock itself was

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compared with *the* standard time keepers the stars, by means of the Transit instrument. Only a few more observations for time were now required on a few succeeding nights to make sure that the clock was going with regularity.

Little now remained to be done before packing up again; a plan of the observatory camp was made, and, as a check on the astronomical method of finding the difference of longitude, one of the observers and the bombardier twice carefully chained the distance from Lord Rodney's statue to the Transit instrument, with a chain tested previous to starting at Trafalgar Square, while the other observer, with a soldier of the 2nd W. I. Regiment as assistant, took the bearings of each change of direction in the chaining with a theodolite.

The Transit of Venus was also carefully observed by two gentlemen who came out from England independently—Rev. Dr. Pearson, Fellow of Emmanuel College, Cambridge, and — Tulk, Esq.: they were both stationed within a few miles of Up Park Camp, and both obtained good results.

Considerable interest was excited by the Observatory Camp; and after the Transit numerous visitors came to look at Jupiter, Saturn, double stars, coloured ones and nebulæ. A lecture on the Transit of Venus was asked for, and Dr. Copeland was about to deliver it in a central building in the town, but this was put off in consequence of the disastrous fire which that night burnt up so much of Kingston.

The gear was then all packed up again, except the old rectangular hut which was sold, as it was not worth the cost of carriage home, and the contractor took the boxes back again, bringing a fire engine, which had been disabled in the fire, as the strongest carriage procurable for the heaviest package. But now a difficulty occurred, the Royal Mail wharf had been much burnt, and men could not be got to work there; the homeward-bound mail, too, would only stay out near Port Royal, some six miles distant across the harbour, as coming from Colon it was placed in quarantine, and it was expected to arrive on Christmas Day, a general holiday; it almost seemed as if the packed-up boxes could not be shipped, but the Ordnance Store Officer, D.-A.-Com.-Gen. Baker, kindly granted the use of his wharf, though it was also a good deal burnt, and he provided several men to load a barge, while the Commodore, Royal Navy, kindly gave the use of a steam pinnace, which tugged the whole to a place near where the mail steamer was expected; all the boxes were safely shipped, and in due course arrived again at Southampton, when the bombardier went round and made good slight defects; and an agent then forwarded them to their various destinations.

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ROUGH NOTES

ON

MOUNTAIN BATTERIES IN INDIA.

BY

CAPTAIN A. KEENE, R.A.

To begin with the mule. The Punjab Mountain Batteries get their mules in the Punjab, and they are perhaps the best (*i.e.*, hardiest) of all mules. They run in height from 12·3 to 13·3 hands in those Batteries, and the price is about 200 rupees. The Bombay Batteries get their mules from Persia. The Persian mules are very good, but the best of them are perhaps a little tall for Mountain Battery work, as they run to 14·3 or 15 hands. These mules cost as much as 300 rupees in Bushire, and are sent thence to Karachi or Bombay as required.

Height. We may take 13·2 to 14 hands as the best height for a gun or carriage mule, and 12·2 as the minimum for a baggage mule. In choosing a mule the points of a weight-carrier must be looked for. Depth of

Girth. girth is the first point, 50 inches being a minimum; 60 inches is a good measurement for a gun mule. Many mules will be found with

Chests. good chests and short strong fore legs. The pasterns cannot be too

Pasterns. straight. The quarters are seldom good. The mule need never be

Quarters. shod. The hoof must, however, be kept carefully rasped when the

Feet. mules stand any time on soft ground, otherwise the horn grows very fast, and breaks when marching over stony ground. No entire mules should be kept in a Battery; they give a great deal of trouble. Gelding

Gelding. is well understood in India, and the farrier of any Native Cavalry Regiment can be trusted to perform the operation. The mule lives to

Age. a great age. In a Battery in which the writer served there were at one time some mules that had served 22 years. Mules are not fit for the heavy loads of a Mountain Battery till four years of age. They will work of course much younger, but will soon knock up. As the mule is only required for slow work, his fodder is of more importance

Fodder. than his grain. The best fodder the writer has ever seen given was equal quantities of lucerne grass and *bhoosa* (chopped straw of barley generally). These being cut up fine together and thoroughly mixed form splendid food. Mules eat any grain; it is not at all necessary

Grain. to soften or crush or grind even barley for them. Half gram and half barley is a very good mixture. The ration for Mountain Battery

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mules is 6 lbs. of grain and 20 lbs. of grass. If food is scarce mules should be taken out to graze. They will pick up food in the most unpromising looking places. The drivers have hold of the mules by their leading-reins while grazing, and the gunners furnish a guard.

Water. The mule is particular about water, sometimes refusing to drink after a long march. In some cases it is merely fancy, as they will drink out of buckets sometimes what they refused from the stream. Always carry as

Grooming. many buckets as you can get hold of. The mule amply repays, by his

Clipping. appearance, a little care in the matter of grooming. Clipping is not

Manes. necessary, as the mule only works at a walk. Manes are generally

Tails. hogged, and can be made neat enough. Mules have seldom good tails.

Line Gear.

Very good blankets are issued to the Mountain Batteries in India; they are made of stout camel-hair cloth, and are bound with tape; there are tapes to tie under the belly, and in front is a flap to pass over the chest, and this is also tied. With two of these blankets a mule can stand any cold or rain.

Mules are picketed by a head and heel-peg each. A chain must always be used for the head fastening, as the mule will nibble a rope. A good tie has yet to be introduced for securing the head chain to the ring in the head stall. Mules eat leather ties, also their blankets. A stick with a hole bored at each end and tied one end to the body roller, and one end to the ring on the head stall, prevents this to a certain extent, as the mule cannot get his head round. Mules suffer from standing in wet ground: cold seems to affect them in this way only. A platform of mud, rammed hard, should be made for the mules to stand on if the Battery is in standing camp, with a low wall in front to prevent the grass from being blown away. If you are getting *bhoosa* (chopped straw[1]) for fodder and there is a high wind blowing, give it to the mules in bags made up like large nose-bags.

Harness, &c.

The pads are made separate, and are very large; this is good, as it gives a large bearing surface, the weight is better distributed, and there is less swaying and racking of the load than with a small pad. Wool is the best stuffing: as much as 16 lbs. is required for a pair of pads; use every artifice to keep up a supply of wool; when in the field, shear the sheep that are issued for the men's food before they are killed. A large hole is left in the side of the pad for convenience of stuffing. Serge is the best material for lining. Over the pads fit a wooden tree, bound where necessary with iron. Each tree is shaped for the load for which it is intended: thus there are trees for the gun, carriage, wheels, ammunition boxes, and baggage, all of different shapes. A baggage saddle can be utilised for carrying an ammunition box by a little care. The tree is fastened by straps to the pads, and has hooks front and rear to which the breast-piece and breeching are attached respectively by links. The crupper is also fastened to a stout

[1] The straw is not chopped, only trodden by oxen, but it comes to the same thing.

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strap running through a D on the back of the wooden saddle. The girth straps pass through slots in the tree, and the girths are tightened crosswise under the mule's chest; over the girths lies a stout surcingle (for the gun and carriage mules, the loads of which require extra steadying), this is also attached to a centre strap passed through a slot in the tree; thus the tree is kept fairly steady on the pads.

Side arms.

On the gun saddle are carried a breech-lifter and a handspike. The breech-lifter is a piece of good wood, with a leather loop attached to an iron ring in the centre; the loop is slipped over the cascable when the gun is to be lifted. The handspike has the bevelled end covered with leather, and is slipped into the muzzle when the gun is to be lifted. On the carriage saddle are two sponges and check ropes. On the wheel saddle (on the top between the wheels) is a box containing fuze implements, the long tangent scale, spare linch pins and washers, &c. On the ammunition mules is carried the line gear of each mule, rolled neatly in the blankets and strapped on the top. Over this roll of line gear is thrown a small tarpaulin neatly rolled, the ends of the tarpaulins passing under the boxes of ammunition in fine weather. If it rains the boxes are raised, the tarpaulin pulled out from under, spread out and fastened over the whole of the mule's load, and secured by the straps which pass from front to rear over the ammunition boxes.

The line-gear of the gun, carriage, and wheel mules are carried on the spare gun, carriage, and wheel mules respectively.

The gunners of the detachment carry a number of useful articles in leather pockets; No. 1 has a short tangent scale, 2 loose fuzes, a hook-borer and a G. S. key; No. 3 has a clasp knife; No. 4 the prickers; No. 5 the lanyard; Nos. 4 and 5 the linch pins and washers; No. 9 a small axe, and so on.

A mule with pioneers' tools, such as shovels, picks, and felling axes, always marches with the Battery. Baggage mules carry tents, light kits, cooking pots, hospital and veterinary medicines, money, office boxes, and so on. It is intended that half the battery should be capable of moving out at a few hours' notice with its own baggage animals.

Gunners and Drivers.

The gunners must be *tall* men; 5 feet 8 inches is the very least. No short man can help in lifting the gun and carriage on to a tall mule. Drivers need not be tall, but must be as sturdy men as you can get, for they have to march like the Infantry soldier, and at the end of the march to attend to their animals like the Cavalry soldier.

The dress consists of a helmet or puggerie, according as the man is a European or Native, a loose Norfolk jacket, knickerbockers, putties or gaiters, ammunition boots or native shoes. The summer dress is of Khakee drill, the winter one of stout blue serge. Officers and trumpeters ride on ponies generally.

Gunners and drivers have a short curved sword slung over the shoulders by a shoulder belt, a waist belt passes over this and pulls the jacket neatly to the waist. Great coats are carried in a horse collar roll. It is better, however, on the line of march to put the gunners' coats on the spare gun, carriage, and wheel mules, and let each driver have his with the line gear of his own mule.

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A havresack and water bottle are carried; a good water bottle has yet to be issued.

Hints about Marches.

Always march in the cool if possible, you can hardly be too early. A mule Battery marches at very nearly four miles an hour when in good trim. At every halt unload all the mules; the equipment admits of this being done so easily, that it will only take about two minutes to take off all the loads, and about the same time to put them on. At half way, relieve your gun, carriage, and wheel mules, by putting their loads on the spare gun, carriage, and wheel mules. Examine all the pads about every three marches. If anything is to be done to the stuffing of a pad the driver to whom it belongs must take it himself to the *moochee* (collar-maker), and do the alteration under him, otherwise the work cannot be got through.

Camping. On arrival in camp, the guns are placed in action in the gun-park. Each ammunition mule is then brought up and unladen in succession. The ammunition boxes are neatly stacked, a foundation being made for each stack, and a trench dug round the bottom in rainy weather. The tarpaulins that were on the ammunition mules are then secured over the ammunition boxes, the side arms and small stores of each gun being placed under the same protection. In the meantime the mules have filed out to water. The Nos. 1, under the superintendence of the Orderly Officer, run out a line to mark the front pegs of the mules of their sub-divisions. The mules are led to their places in succession: the drivers throw out their head and heel pegs, which are driven by the gunners. Girths and cruppers have been loosened for watering; the drivers now unroll their line gear, put on the line gear head collars, dust their harness, &c. After about 15 minutes sound "off saddles," then, 10 minutes after, "stables;" half-an-hour's grooming is enough if the men are tired; you can make it up at evening stable hour. Feed at the end of stables. You must always carry a day's grain with you. In the evening let each driver bring his marching order nose-bag and take a feed for the next day.

A mule Battery can go anywhere where an Infantry soldier can go without using his hands and knees. Always give mules their heads in steep ascents or descents. Always carry water in *mussucks* on a spare mule. Always try to have the Battery ready to split up into three divisions: this is difficult, as the establishment is not calculated for such an emergency; the emergency however occurs regularly in every campaign, and you will find one division has no carpenter, another no shoeing-smith, another no trumpeter, one has no collar-maker, and so on.

Always try and have some ready money with you, as the Commissariat will probably ask you to arrange to feed your own mules.

The guns should be worked by the detachments kneeling. A better arrangement in the matter of check-ropes is urgently required. The 7-pr. (200 lbs.) recoils a great distance when fired at a high angle.

A heliograph should be issued to each Mountain Battery, as they are so often on heights whence they can use them with great benefit.

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NOTES

ON

CERTAIN ROUGH METHODS

OF

APPROXIMATING TO LATITUDE AND LONGITUDE DETERMINATION, WITHOUT INSTRUMENTS.

BY

LIEUT. T. P. BATTERSBY, R.A., F.R.A.S.

It appears to me that a note on the above subject will form a useful appendix to the late papers, by Lieut.-Col. J. R. Oliver, in the "Proceedings of the R. A. Institution." It is true that very few occasions are likely to occur where an observer will find it advisable to ascertain his locality, and has no instruments whatever at his disposal; but nevertheless the case is possible. As an example, he may have been blown away in a balloon and landed at some unknown part of Africa, Australia, or South America, and may there have made a discovery of one kind or other, say a rich vein of metal, or a noble lake, or the haunt of a yet unknown animal, which makes him desirous of fixing in some way the position of the spot before he leaves it on his journey back to civilization. And moreover it is the man who is able to take advantage of the meagre materials at his service, and use them to best effect, who is most likely to do good work when really good instruments are at his disposal. Therefore I make no further apology for mentioning, as briefly as possible, a few simple expedients, which if made with care, would, I think, be accurate enough in their results to fix the position of a place within such limits as would make it easy to re-discover.

We will then suppose our explorer landed in an unknown spot with no instruments of any kind in his possession save his watch, a penknife, and a note book. Fortunate will he be if in addition he happen to have an English halfpenny in his pocket, for as that coin is just an inch in diameter he will at once have a unit of length at his disposal; should such not be the case he must cut for himself a slip of wood, adopt it as his basis of measurement, and carry it home with him for future comparison.

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His very first proceeding must be to obtain a rough meridian line: for this purpose he will cut for himself a tall stake or lath of wood, make a slit in the top, and insert there a thin plate of any material most readily available, probably the bark of a convenient tree. For future observations he will drill a small hole in the centre of this plate, and carefully measure the exact height of the said hole from the ground when the stake is planted upright. If he be fortunate enough to have a piece of string in his possession, or to be able to fashion a substitute, he will ensure the uprightness of his gnomon by fastening the end of the twine to the top of the stake, and noting that when the latter is truly vertical the other end of the string will just touch the ground at points equally distant from the foot of the stick.

Having arranged these preliminaries, and placed the stake so that the flat piece is as nearly as possible opposite to the position of the sun at its highest culmination he will now wait for the noonday. The sun shining through the small hole will trace a luminous disc of light in the midst of the shadow cast by the plate, and this disc our observer must follow with great care, perpetually measuring its distance from the foot of the pole, and marking off its position by lines drawn on the ground. When the said distance, which has been continually shortening as the sun rises higher and higher, has reached its minimum and begins to increase again, he at once plants a peg in the last position, and then the line between this peg and the stake will be approximately in the meridian: moreover he will be able from the same observation to note roughly the tangent of the sun's altitude, which is obviously equal to height of stake ÷ distance of latter from peg. The value of this should be carefully set down in his notebook, and should be observed every day the sun is shining. When he again reaches civilization he will be able to make a fair approach to his latitude from the mean of that obtained from these various observations.

I may remark here that in this paper I purpose only to treat of the Northern Hemisphere, as, where the observations do not apply to the Southern (as in the case of the Pole Star), or where slight alterations, such as the transposition of North for South would have to be made, the corrections are so simple as not to make it needful to refer to them.

Having now a rough meridian line, our observer may use several other measures for determining the latitude, and I should advise all of them to be employed, so as, as far as possible, to neutralize the effect of errors in each individually. He may trace out a circle on the ground (by means of his string and a peg or two), having his meridian line for diameter, and by the usual geometrical methods divide it pretty accurately into degrees. Now every evening that the sun sets in a clear horizon, let him note by a plumb-line at what point the said setting takes place, remembering that the true moment of disappearance of the real body of the luminary is when its lower limb touches the horizon. When a logarithm book is again available he may utilize these observations by the following formula:—

Secant of latitude = sine of amplitude ÷ sine sun's declination. The results gained thus are likely to be very rough indeed, but may be valuable for correction.

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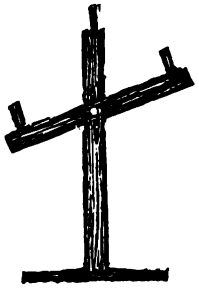
Neither of the above methods can of course be used on the spot by our observer, as the sun's declination is to him an unknown quantity, which he has no means of ascertaining. The only way in which he can arrive at the roughest determination of his latitude at the time of observation is therefore by observation of the Pole Star, whose altitude is of course the exact quantity required. For observing this he must devote his attention to constructing a protractor, which, with a little trouble, can be marked off with some approach to accuracy, provided he has anything to mark it on. If nothing better offers, I would suggest his own pocket handkerchief, very tightly stretched on a piece of wood or stone. The larger the scale the better, as there will be less chance of error.

Now on the side of his upright stake, and as nearly as possible parallel to his meridian line, let him carefully attach a cross piece of wood working stiffly on a pivot; on the upper surface of this piece let him fix two small uprights with notches cut in the top, taking extreme care that when the lath is horizontal the line between the notches is also so, as nearly as can be ascertained. Let him now wait till the line joining the Pole Star and the Pointers is nearly parallel with the horizon, when the star itself will be slightly out of the meridian, but at its mean altitude, and then endeavour to observe it by the two notches. A bright moonlight night will be best for this purpose as, though the star itself will be fainter, the notches will be visible, and on a dark night they probably will not. The angle between the upright and the cross-piece can be read off on the protractor in the morning, and subtracting 90° from it, the remainder will be the latitude. It will be an exceedingly rough approximation, but better than nothing. All the above methods should be repeated, and their results noted down as often as is at all possible.



Should the observer be fortunate enough to note the occultation of a 1st or 2nd magnitude star by the dark limb of the moon, he must pay great attention to the phenomenon, as also to that of a star just escaping occultation. In the former case he should mentally divide the circumference of the moon into hours as the dial of a clock, and thus note the exact place where the occultation occurred. This can be done with surprising accuracy by anyone who has practised it. The entry may be made after the following fashion:—

"June 6th. Occultation of star about 9.45 p.m. Place on moon's disc 10.30."

Such an observation may be of the greatest use in determining the latitude, and even of some in fixing the longitude. Should the star just miss occultation, and the moon pass above or below it, then the observer should note at the instant of nearest approach the apparent distance of the bodies apart in terms of the moon's apparent diameter (measured if possible from the *dark* segment, as the bright one is unnaturally enlarged by irradiation). If he prefer to *measure* the distance, he may do so roughly by means of a stick with a notched

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upright at one end, and a cross-piece at the other divided off into lengths, subtending say 15′ of arc each (they would be about half inches if the stick were 9½ feet long); but my own opinion is that it can be done more accurately by simple eye estimation.

Unless the star be at an unreasonable distance from the disc, it is sure to have been occulted by the moon at some part of the earth's surface, and the observation will be a most valuable check on latitude determination.

As for longitude, that is a much harder matter, for without a telescope the observer has no chance of obtaining Greenwich time (had he even a good opera glass he might obtain it roughly by an eclipse of one of Jupiter's satellites), and so must depend entirely on his watch for aid.

Should he have been carried off in a balloon, it is just possible that he may have observed the time the sun rose or set on the previous day at the place of departure, and in that case he has only to note the time again at his new station, and allow one degree of longitude to each four minutes of time, east or west, according as the case may be. He may subtract or add a minute or so for the difference of the sun's declination according to the time of year, but as the latter is always varying, and the error of his watch will affect the result, even in this most favourable case he will not expect to be right to within a degree. But even that will be a great guide to his position.

If he be simply on an exploring tour, and have lost his instruments by accident, he will be certain to have some knowledge of his whereabouts from his last observations, so I do not consider this case particularly. If, however, he has not noticed the time of sunrise or sunset, and, as I pre-suppose, has no almanac with him, he must give up all hope of doing more than ascertaining facts sufficient to enable him to calculate his longitude on his return.

We must presume that he started on his journey with his watch set correctly. Now his great object must be to preserve its rate of going as constant as possible, and to make as many observations as he possibly can on the first day or two, while the error of time is at its smallest. If he have a flannel shirt on, let him cut a piece off and keep the watch wrapped in it, in the same position if possible, both by day and night, and let him wind it both morning and evening, that the mainspring may keep at a pretty constant tension.

Now over the peg which marks his meridian let him erect a cross frame with a plumb-line hanging down directly above the peg. This line and the upright stake will form a very rude transit instrument, which he may improve upon as occasion offers, and ingenuity serves. With it he must observe and note the daily time of the sun's meridian passage, and that of the transit of all the first magnitude stars (which I presume he can recognise! It should certainly be one of the most elementary lessons learned at our schools, but I fear is not). He will soon remark any considerable variations in the rate of time kept by his watch, by remembering the fact that the same star will transit about four minutes earlier on each night. When he returns to the happy region of nautical almanacs and logarithm tables, he will easily be able to reduce his observations, find out whether the rate of his

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watch had been constant, and if not, on which days it varied most, and so obtain the required longitude with some degree of accuracy. Should he chance to have been cast away on his unknown country about the time of the longest day it will be worth his while to observe on how many days about that period his gnomon casts no shadow. If on only *one* he is on the line of the Tropic of Cancer or Capricorn, according to his hemisphere; if on none at all he is outside the tropics; if on *two* days, separated from each other by an interval increasing as the latitude is less, until it reaches six months at the Equator, he is within them.

I have never had the opportunity of trying the above rough methods myself, but I have no doubt that, by means of them, a careful and painstaking observer could note down data enough to enable him to find a locality again; and it is, or at least may be, of practical utility to be able to do this without instruments. I may add that the meridian line obtained from the sun may usefully be checked by the Pole Star and the Pointers, when the latter are vertical, by means of a plumb-line.

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MEMOIR

OF

GENERAL SIR W. F. WILLIAMS, G.C.B.

September 2nd, 1883.

DEAR MAJOR HIME,

From your last note it appears to me that my personal reminiscences of Sir Fenwick Williams will be most useful to you, and I will therefore endeavour to give you a sketch of them, though it must be very hurriedly.

Sir Fenwick was one of those unfortunate Cadets who was kept at the Academy for some six years, owing to the great reduction in the Army that followed the Battle of Waterloo. His elder brother, commonly called "Bruin" Williams, served with distinction in the Peninsular War. Sir Fenwick in the early part of his career was for ten years in Ceylon and India. After returning from thence he was employed at Constantinople, at the Tophaneh or Arsenal, at the same time as Sir Collingwood Dickson. Subsequently he was chosen to act as British Commissioner for the delimitation of the Turko-Persian frontier with the Russian General Cherikoff and a French Commissioner, whose name I cannot at the present moment remember. The work must have been extremely arduous, but the opportunities of becoming conversant with the characters of all classes of people in Asia Minor very great. The strained relations between England, France and Russia put an end to the works of the Mission. When war was declared it was decided to send a Commissioner to represent the Queen of England to the Army of Anatolia. The English Ambassador at Constantinople, Lord Stratford de Redcliffe, then all powerful, arrogated to himself the right of nominating the Commissioner. It is needless to say that such right was ignored by the then Minister for Foreign Affairs, Lord Clarendon. It is now a matter of history how Sir Fenwick Williams was, if not absolutely thwarted, at all events, ignored, and left unassisted by the Ambassador during all his work; but the reason, simple as it is, has never been publicly understood. Sir Fenwick was not the Ambassador's nominee, and, unused as he was to any sort of opposition, he determined to show that any one not chosen by himself, could not possibly be the right person for so important a post. In July, 1854, Colonel Williams, who was then in England, was suddenly sent for and offered the post of Queen's Commissioner with the Army of Anatolia. He accepted, and left England at a

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moment's notice. Travelling by what was then the quickest route, and leaving baggage and servants to follow, he arrived at Constantinople, and a few hours afterwards rode to Therapia, and had an interview with the Ambassador. He saw him once or twice again, and then proceeded to Varna, where he saw Lord Raglan, and returned to Constantinople. As soon as ever the baggage and camp equipage could be got together he left by steamer for Trebizand, without having been presented to the Sultan or Seraskier, and without any notice having been sent of his arrival, or the attentions due to his position. A march of seven days brought him to Erzeroum, where for the first time he heard in some detail of the wretched state of the Turkish Army that had been beaten back into Kars after the disastrous Battle of Kuruk Déré; without a moment's unnecessary delay he at once made his way to Kars, and began his investigations. Nothing could exceed the state of disorganisation in which the so-called Army then was. From the imperfect way in which he was accredited to the Army, every difficulty was thrown in his way with regard to information; but he was not one to be baffled, and soon found out from personal observation that the number of men on paper was nearly double that which could be produced on parade. Transport and medical service hardly existed; ammunition was at the lowest ebb; and the troops, besides being in some cases eighteen months in arrears of pay, were fed from hand to mouth, and no stores of provisions were laid in. All these and many other things were reported to the Ambassador, and under flying seal to Lord Clarendon and Lord Raglan. Luckily the Russians lost the opportunity of walking into Kars, and the winter came on. A garrison of about twelve thousand men was left at Kars, and the rest of the troops were sent to the villages and Erzeroum. Sir Fenwick went there and laboured incessantly to try and get supplies and reinforcements sent up. Unfortunately his despatches were ignored, and all that he could do, after a terribly severe winter, was to commence the work of fortifying Erzeroum and the Deveh Boyounou Pass. While engaged on the latter work, news came that the Russians had moved from Gumreh in force, and were advancing on Kars. This was in the early days of June, 1855. Sir Fenwick at once left by forced marches, and arrived in time to steady the garrison, and push on the work of entrenchment that had been carried out from the first available moment by Colonel Lake. The redoubts were already in fairly good order, and the epaulments which connected them were pushed forward as quickly as possible. The Russians steadily advanced and endeavoured to make the first attack on the 16th June, the day of Bairam. They expected to surprise the garrison, but finding them thoroughly prepared, the affair ended in a reconnaissance in force, and the Russian Army then encamped in the plain opposite the town and on the road to Erzeroum. Finding how weak the garrison was, particularly in Artillery and Cavalry, the Russians moved to a point, cutting the road, to Erzeroum and in a very strong position. The Commander-in-Chief, Mouravieff, then took a strong force towards Erzeroum, leaving the rest of the Army to mask Kars, and during his absence an attack was made from the plain, which resulted in a somewhat bloody repulse of

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the Russians and the return of Mouravieff. During all this time, General Williams had laboured night and day at the works. Every night his officers patrolled the front allotted to them, and as the day broke found the General at the advanced post ready to receive their reports. He had so far gained command of the garrison, that every morning before daylight the whole of the lines were manned quietly, the reserves were under arms, the strictest watch kept up, and no sign of movement to be seen from outside. The Cavalry became more than ever useless, and had to be sent away. The Artillery horses were in so miserable a state that the guns had to be left in the redoubts. The news of the Fall of Sebastopol came and cheered every one; but still no help reached the place. On the night of the 28th September, the Russians left their camp at dark, keeping up all the fires: and at half-past three on the morning of the 29th, Kars was attacked by the whole of the Russian Army; it consisted of the *élite* of their men, all old soldiers of the Caucasus; their Infantry was about 45,000, Cavalry six or seven thousand, and some sixty guns; the result is well known. Owing to General William's foresight, every man was at his proper post. From the long studied and carefully prepared lines the fire crossed upon the heads of the Russian columns. To the points at which they succeeded, General Williams sent his reserves, and re-took the carried position with the bayonet, and finally after seven hours hand to hand fighting, the enemy retired with a loss, owned to by themselves, of 8000 men *hors de combat*. The Turkish account of buried Russians exceeded that number. For two long months after that there was no more meat to give the men. Fifty or sixty per day died of cholera, many more of fever, wounds, and exhaustion, and at last 200 a day from famine. Still no help. Omar Pasha's *fiasco* never diverted a bayonet from the besieging force, and so the inevitable end came in the last day of November. Those who thought that Sir Fenwick Williams would be unequal to his post knew him little. Under ordinary circumstances he might apparently have remained an ordinary man; but as were the dangers and difficulties of his position so were his resolution and power to overcome them. He had marvellous self-reliance, and perfect fearlessness of responsibility. He trusted his subordinates, but only consulted with them on points of detail. He would walk for hours alone working out plans and ideas in his mind, and, once settled, they were never departed from. Every one knew that an order once given had to be obeyed without comment. Firm as a rock on duty, he had the kindliest, gentlest heart that ever beat. In England he found no scope for his gifts, and others can tell you better than myself of all the good and important work he did in America: and he never ceased to serve until his health completely broke down at Gibraltar, and he returned to England a wreck of his former self to linger on and die beloved and regretted by every soul who had ever known him.

Very truly yours,

C. C. TEESDALE,
Colonel, R.A.

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NOTES

ON THE WORDS

GUN, GYN, AND PELLET.

FROM the "*Promptorium Parvulorum*," an English-Latin Glossary, compiled by Father Galfridus, a Dominican Friar of a Monastery at Lynn, Norfolk, in 1440: edited by Mr. Albert Way, and published by the Camden Society, 1865.

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THE SECRETARY.

[Some of the facts and authorities quoted in the following Notes have been already quoted in the "Proceedings" by Lieutenant (now Colonel) Henry Brackenbury, in his exhaustive and able papers entitled, "Ancient Cannon in Europe," "Proceedings," Vol. IV. p. 287, and Vol. V. p. 1. It was considered desirable for many reasons, however, to reprint the Notes as they are, intact.—*H. W. L. H.*]

(GUNNE, S. P.) *Petraria*, DICC. *et* COMM. *mangonale*, KYLW. *murusculum*, C. F. *gunna, et idem est fictum* (*magonale*, P.)	GUNNARE, or he þat swagythe a gunne. *Petrarius, mangonalius.*

MR. WAY'S NOTE.

"A gunne, *fundibalum, murusculum.* A gunner, *fundibalarius, fundibalista.*" CATH. ANG. written A.D. 1483. The difficulty of ascertaining with precision the period of the introduction of engines from which missiles were propelled by means of gunpowder arises chiefly from the circumstance, to which allusion is made by Selden, that the term gun, supposed by Somner to be merely a contraction of *mango*, or *mangona*, may have been used to denote some engine of war, long before the application of gunpowder to such purpose. Mr. Douce observes that the earliest mention of "gonnes" is found in the Romance of Kyng Alisaunder, line 3268; but in his note on that

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passage he says that it must not be concluded that they were used with powder, as originally they might have been engines of the catapult kind. Weber, Metr. Rom. iii. 306. The same remark applies to the account of the siege sustained by Kynge Aragus, who

> ———" ordeyned hym ful well
> With gonnes, and grete stones rounde
> Were throwen downe to the grounde." Syr Tryamoure, 955.

In the Avowynge of Kyng Arther, a "gunne" is mentioned, the effect of which is compared to lightning, but it is still doubtful whether the term should be understood to imply a projectile impelled by any ignited substance, or merely filled therewith.

> "There came fliand a gunne,
> And lemet as the leuyn." St. 65, edit. by Mr. Robson.

It seems very probable that the missile here intended was a tube filled with Greek fire, or *feu volant*. In several MSS. of the Practica of John Arderne, a surgeon of eminence *t.* Edw. III. instructions are found for compounding *"fewes Gregois"* and *"fewes volants:"* the latter being a liquid mixture, described as of an oily nature, with which a pipe being filled, and ignited by a match, would fly in any direction. A figure is given the margin. He proceeds to describe *"fewe volant"* of another kind. *"Pernez j. li. de soufre vif, de charbones de saux,* (*i.* weloghe,) *ij. li., de saltpetre, vj. li. si les fetez bien et sotelment moudre sur un piere de marbre, puis bultez le poudre parmy vn sotille couerchief. Cest poudre vault à gettere pelottes de fer, ou de plom, ou d'areyne, oue vn instrument qe l'em apelle* gonne." See Sloane, MSS. 335, 795. A detailed account of passages in ancient documents or chronicles which throw light on this obscure subject has been given by Sir S. Meyrick, in his Crit. Enquiry, and a paper on the history of hand fire-arms, Archæol. xxii.; and likewise by Mr. Archibald, in his description of ancient artillery discovered on the coast of Lancashire, Archæol. xxviii. It may here suffice to state that gunpowder was known in Western Europe about the middle of the XIIIth cent.; and that the earliest recorded instance of its use in war, in this country, appears to have been in the first expedition of Edward III. against the Scots, in 1327, when artillery, termed by Barbour "crakys of wer," was employed. See Jamieson. There can be no doubt that Chaucer uses the term "gonne," to signify an engine charged with gunpowder; as in the following comparison:

> "Swift as a pellet out of a gonne,
> When fire is in the pouder ronne." House of Fame, B. iii.

The Household of Edw. III. as appears by the ordinances which commence 1344, printed by the Ant. Soc., comprised "Ingyners lvij. Artellers vj. Gonners vj." Their daily pay in time of war was 6*d.* The invention of hand fire-arms is assigned by Sir S. Meyrick, on the authority of Billius, to the Lucquese, in 1430; (Archæol. xxii. 60) yet

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a prior use of some weapons of the sort seems to be indicated. In an Inventory of the arms and effects of Sir Simon Burley, taken apparently after his execution, 1388, and now in the possession of Sir Thomas Phillipps, among "*petites choses à* Baynard Castell," is named "*j. petit* gonne *de feer*." In the Pell Records, 1 Henry IV. 1400, payments appear for "quarell gunnes," at 7*s.* each; for saltpetre, sulphur, and wadding; and the contemporary evidence of Monstrelet shews that "*bastons à feu*" were among the arms of the English sent to the relief of the siege of Orleans, in 1428. Hand-guns are named among purchases for the defence of Holy Island, 1446; and were used at the siege of Caistor, in Norfolk, about 1459. Paston Lett iv. 316. In the version of Vegecius attributed to Trevisa, and completed 1408, in the account of military engines, allusion is made to "grete gonnes that shete now a daies stones of so grete peyse that no walle may withstonde them; as hathe be wele shewede bothe in the Northe cuntre, and eke in the werres of Wales." B. IV. c. 22, Roy, MS. 18 A. XII.

GET, or GYN' (gett, or gyle, K. gette, or gyty, S.) *Machina.*

MR. WAY'S NOTE.

A gin signifies, according to the old writers, a cunning or deceitful device, and thence an ingeniously constructed machine of any kind. Chaucer uses the word in both senses; thus the crafty trick of the Alchemist, which is termed "a false get," as has been observed in the note on the word GET, is called also "a false gin." In the Squire's Tale it is related that the magical steed of brass would bear its rider at pleasure,

> "And turne again with writhing of a pin;
> He that it wrought, he coude many a gin."

In the Golden Legend, the wiles of Satan are termed "gynnes of temptacyon," Life of St. Bernard. In the Romance of Coer de Lion warlike machines are termed gins; as they are continually in Trevisa's version of Vegecius, Roy. MS. 18 A. XII. "*Troclea,* the gyn whyche is called a crane." ELYOT. See Hartshorne's Shropshire Glossary. "*Exostra,* a vice or gin of wood, wherewith such things as are done within, out of sight, are showed to the beholders by the turning about of wheeles." Junius's Nomenclator, by Fleming.

PELOT, rownde stone of erthe, or other mater (pelet, H. P. *Pileus, vel piliolus, rudus,* C. F.

MR. WAY'S NOTE.

The term pellet, Fr. *pelotte,* designated the stone balls, or missiles which were projected by the mangonels, and warlike engines of

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early times, and by Artillery . . . . . Missiles formed of indurated clay have also been found, the use of which is perhaps indicated in the Promptorium. In Golagros and Gawane, v. 463, are mentioned "pellokis paisand," with "gapand gunnis of brase;" and Chaucer uses the simile "swifte as a pellet out of a gonne." House of Fame, iii. Horman says, "The messenger was slayne with a pellet, *glande*," and Hall speaks of shooting "great pellettes, whiche made a greate noyse." Chron. 24 Hen. VIII. "A pelet of stone, orlede, *glans*." CATH. ANG. "Pellet, a rounde stone, *plomme*." PALSG. See Mr. Archibald's observation on stone shot found in the island of Walney, Archæol. xxviii., and Mr. Porrett's notice of shot found in the Tower moat, Archæol. xxx. Compare CALYON, rounde stone, *rudus*, p. 58.

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ROBERT GRAHAM'S PETITION.

COMMUNICATED BY

LIEUT.-COLONEL J. A. TILLARD, D.-A.-A.-G., R.A.,

With the sanction of the D.-A.-G., R.A.

15 Feb., 1818.

THE Petition of ROBERT GRAHAM, Gunner in Major Charles Younghusband's Company, 4th Battalion, Royal Artillery, now lying at Tynemouth Castle, in the County of Northumberland, and under the command of Lieutenant Evan Morgan.

To the Honourable Board of Ordnance, humbly sheweth that:—

Ye mauna think me self-sufficient,
Nor yet o' common sense deficient,
But kenning ye are quite efficient
Me to enlarge,
Frae durance vile, when thus petition'd,
Me to discharge.

Five years I've sairt His Majesty,
Wha now could weel dispense wi' me,
Gif that ye only could agree
Yoursel's amang
To set me at my liberty
An' let me gang.

I've sairt the King in peace and war,
But free o' scaith an' free o' scar;
An' now wi'out me I'm awaur
He weel could reign,
Ow're His domains, near an' afar,
In peace a King.

I hae a sister an' a brither,
Besides an auld an' widow'd mither,
Whilk if 'twad please ye to send thither
Your humble servant,
Our thanks ye'll hae them a' thegither
An' prayers fervent.

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They're steep'd in portith to the lip,
Stern poverty it does them grip,
Affliction's cup they af'times sip
Unto the dregs:
'Tis for to help them han'-an'-hip
Your servant begs.

I hae nae siller, ye may see,
In lieu o' service for to gie,
Or I had nae ha' troubl'd ye,
At a' this time,
Wi' this the earnest wish o' me,
In auld Scotch rhyme.

Sae, gin an order ye wad gie
That I might straught dischargèd be,
An' send it straughtway down to me,
I'll thank ye a'—
Ye honourables, honourably—
Baith grait an' sma'.

Lang hae I been frien's wi' the Muse;
She's kind—then dinna ye refuse;
An' I your favour won't abuse,
But set aff hame,
An' thank ye lang as e'r ye chuse
While my name's

GRAHAM.

Memorandum from Lord Mulgrave.

Sir Robert Moorsom may write an answer, either in English or Scotch verse, saying that the times at present will not admit of his being discharged, but that his name shall be noted to be one of the first to be discharged.

J.R.C.

3rd March, 1819.

Second Petition to the Honourable Board of Ordnance:

That:—We're tauld to ask, an' we'll receive;
But how can I that text believe,
Sin' ye yoursel's did me deceive—
At least forgot
To keep the promise whilk ye gave
When last ye wrote.

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Ye said I should dischargèd be
At the first opportunity;
But waes my heart I've lived to see
That ye've forgot it—
Altho' the clerk wrote word to me,
"Your name is noted."

A weary towmond now is past
Sin' I received your first an' last;
There's mōny free wha then war fast,
Still I remain!
Some pity deign on me to cast,
An' loose my chain.

The very Company I belang to
Hae let off chaps baith stout an' strang too;
For God's sake (there can be nae wrang to
Mention His Name),
Sen' me to that place I belang to,
Alias hame.

Gin there's a God-like gift e'er given
To us on Earth frae Him in Heaven,
'Tis that whilk haes the heart that's riven
Wi' care an' grief:
Just twa-three words to Woolwich driven
Wad bring relief.

Then for the Lord's sake order ye
That I may soon dischargèd be;
An' let it be peremptory,
Or they'll no heed it:
Just tell them that I maun be free—
That ye've decreed it.

O to my cry then do ye list!
The like o' me'll ne'er be miss'd!
An' may ye a' live lang and blest
Wi' ne'er a care;
An' aye get that for whilk ye wist,
Sae e'ens my Prayer.

ROBERT GRAHAM.

N.B.—Gunner Graham obtained his discharge from the Royal Artillery on 4th April, 1819. But before that event a letter would appear to have been written by the Adjutant, 4th Battalion, from

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Woolwich, offering him promotion to the rank of Non-commissioned Officer if he would prefer that to discharge.

A copy of that letter has not been preserved; but the following is a copy of Gunner Graham's reply:—

Tynemouth Castle, March 20, 1819.

SIR,—I received your letter this morning, which communicated the sincerest sensations of pleasure that I ever felt in my life.

With respect to my talents, I feel myself obliged to say that they are not worthy the consideration of any person, and they are not calculated for military employment. I can only read and write; and you (in this letter) have a specimen of my abilities in the latter particular.

My character (I am proud to say) has been uniformly good (in a military acceptation of that word); yet I am but mortal, and soon might forfeit all pretensions to that distinction.

I am gratefully sensible of the kind notice that General Cuppage has been pleased to take of me; but I beg leave to decline the honour, as I do not feel my abilities equal to the situation for one good reason—I want the grand military essential, decision of character.

As I am perfectly sensible that I cannot be happy in the Army, your discharging me will confer a blessing that will ever be gratefully remembered by

Your most obedient humble servant,

ROBERT GRAHAM.

To CAPTAIN WYLDE,
Adjutant, 4th Battalion, R.A.

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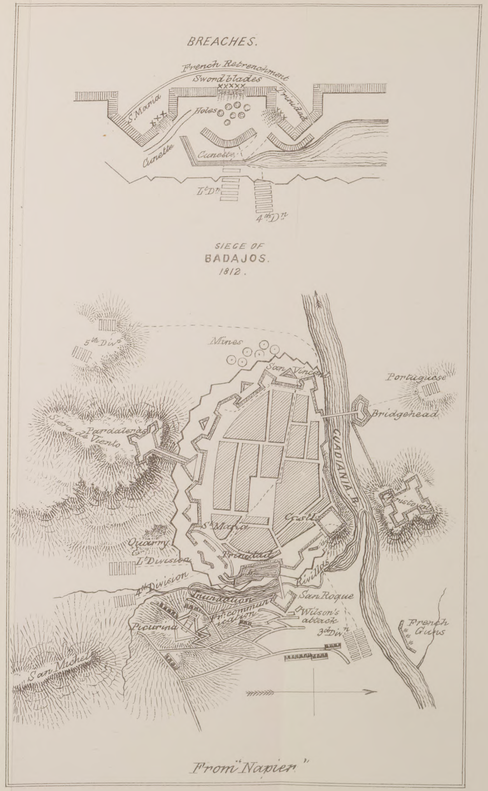
Napier's "Peninsular War", Vol IV, p, 113.

A Sketch of Badajoz.

Taken from opposite to the Bastions Nos 1 and 2 by an Officer of the Royal Engineers.

After an old plate in the R.A. Institution.



From "Napier"

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VENT OBTURATORS.

BY

MAJOR G. W. HAWKINS, R.A.

THE system of venting guns radially from the top, which was convenient enough while ordnance were made of comparatively small dimensions, is totally unsuited to the largest pieces of the present day, in which the process of climbing to the top of the gun, inserting a tube, and descending before firing, would materially increase the time occupied in loading and the danger incurred by the gun detachment. The difficulty was partially met in the R.M.L. guns, 10-in. and upwards, by placing the vent at an angle of 45° with the vertical, and thus facilitating the operation of inserting the tube; but this was only a palliative, not a remedy. A question that runs parallel with this of the best position of the vent is that of preventing the escape of gas by the same orifice. This gas escape scores the vent, and causes it to require frequent renewal—an operation that is at all times tedious, that requires skilled mechanics to perform it, and that places the gun *hors de combat* while it is being done. When it is stated that vents have become unserviceable after firing only 21 rounds, it will be at once seen how desirable it becomes to do away with so constantly recurring an operation. It was hoped also that sealing the vent would increase the "life" or number of rounds the gun was capable of firing.

Axial Vents.

It has long been evident that the most convenient position for the vent, especially in the larger ordnance, is through the breech, and in the axis of the bore. Accordingly, we find guns so vented proposed by Sir Joseph Whitworth in his earliest ordnance and shown at the Exhibition of 1862. There were then two objections to this method of igniting the charge. First, the discharge of the tube and the rush of gas to the rear were troublesome and dangerous to the gun detachment, and though this was obviated to some extent by the use of a shield there was still a very great escape of gas, and the addition of the shield greatly increased the fouling round the breech. The other objection was of even more importance. With the small-grained rapid-burning powders then in use igniting the charge in the centre, was found to produce heavy and uncertain pressures upon the gun, and as it was not considered that this was counterbalanced by the obvious advantage of causing all the material of the cartridge to be automatically removed from the bore, this method of igniting the charge was for the time abandoned.

But with the slow and regular-burning powder now used with the larger ordnance, or with the smaller-grained powders when due attention is paid to air-spacing, these abnormal pressures are not found to occur; and the greater convenience of an axial vent above

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alluded to, the fact that it gives the greatest velocity with a given charge, and last, though by no means least, that it affords the greatest facilities for the use of a vent obturator have combined to cause its reintroduction in the latest type of ordnance. Many different methods of preventing the escape of gas through the vent have been from time to time proposed, and some of them have been tried. Among those more particularly calling for notice are that of Colonel Maitland, who placed a copper plate next the vent *inside* the gun. Quick-match carried the flame round the plate to the cartridge, and on the explosion of the latter the copper was firmly jammed against the inside of the vent and prevented any escape. This principle has been adapted by Hotchkiss to a metallic cartridge in a very ingenious manner. He has two plates of which that at the breech end has a central hole, and the one in front of it three holes not in the centre, and so arranged that when the two plates are firmly pressed together there is no continuous hole through them. The explosion of the tube acts through the central hole of the rearmost plate, and with sufficient force to move the front plate forward and allow the flame to find its way through the three holes to the charge. On the explosion of the latter, both plates are firmly jammed against the solid breech of the metallic cartridge, and effectually prevent the escape of any gas in that direction. In a French method of adapting the vent-sealing principle to radially-vented guns, a percussion tube is fired by a steel bullet falling in a vertical box. On the explosion of the charge the bullet is blown back, and closes the hole through which it was suspended.

Service Vent Obturators. The vent obturators that have been adopted in the service are the vent-sealing primers of Sir William Armstrong, and the vent-sealing tubes of R.L. design. There are two kinds of each—the electric and mechanical; and in both the obturation depends on an accurate mechanical fit between the exterior of the vent-sealer and the vent, supplemented by the expansion of a thin portion of elastic metal forming the substance of the tube or primer. Besides this, it is necessary in all friction and some percussion tubes to prevent the escape of gas through the tube itself, and this is arranged in various ways.

Armstrong Primers. The vent-sealing primers are bought by contract from Sir William Armstrong, Mitchell & Co., for use with the 6-in. B.L. 80-cwt. (80-pr.) gun only. They are made of an alloy of the same metals, but somewhat harder than gunmetal.

Electric. The electric primer (*see* Fig. II.) has two holes bored at the rear end, through each of which passes an insulated copper wire, which is attached inside to a brass wire plug made of such shape and dimensions (*a*, Fig. II.) as effectually to close the hole should it be forced into it. The two brass wire plugs pass through a cylinder of ebonite (*b*), and their points are connected by a platinum wire imbedded in a priming of dry guncotton wool (*c*). Below this priming are two pellets of pressed gunpowder, having a central hole so that they may act on the same principle as a tube, and the end of the bore is closed with a thin cork. At this end the tube is reamered out until it is very thin at the point, so that the gas generated by the two pellets may easily act upon it, and press it back against the sides of the vent, so that the

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greater pressure from the exploding charge may find a joint already sealed, which it tends to close the more securely. The copper wires which convey the electric current are insulated by silk and varnished, and are twisted together for about 18 inches outside the head, when they terminate in bared ends ready for attachment to the "gun points," as the wires from the battery are called. The bridge has sufficient resistance to fire the primer under ordinary conditions, but as the contractors are not tied down to any definite resistance, its electric conductivity cannot be tested with the same ease and safety as that of the R.L. pattern.

Mechanical. The exterior form of Armstrong's mechanical vent-sealing primer (*see* Fig. I.) is the same as that last described, and it also has the two pellets of pressed gunpowder and the chamfered end closed with cork; but the firing arrangements are, of course, different. (*a*) is an anvil carrying an ordinary percussion cap and fastened into the body of the primer at (*b*) by means of a base, through which are four holes (*h*) to allow of the flame passing into the interior of the primer, and over which the metal of the body is spun. Round the cap is a priming of loose F.G. powder, and opposite to its crown is the point of a steel firing-pin (*c*), which passes through the axis of the primer and terminates in a steel disc flush with the exterior of its head. The hole through the axis is slightly enlarged round and under this disc (*d*) to allow for the movement of the firing-pin. The edge of the hole round the point of the firing-pin at (*e*) is raised into a slight ridge so as to resemble the collar of a Bramah press and with the same object.

The gun is fired by a hammer which acts on a striker arranged in a similar manner to that of a central-fire sporting gun. This moves the firing-pin of the primer which fires the percussion cap, and so ignites the charge.

Vent-sealing Tubes. We now come to the Service vent-sealing tubes of R.L. manufacture. These are made of very mild steel, prepared by the Siemens-Martin process, and after being roughly stamped into shape and annealed are bored and turned so as to make as accurate a fit in the vent as possible, after which they are electro-plated with copper to prevent the corrosion which would be certain to occur with bright steel, and which would of course prevent the mechanical accuracy of fit, upon which the success of their action depends. After this they are lacquered, to prevent contact between the metal and powder, and filled with two pellets, pierced with the central hole, and pressed from R.F.G. or R.F.G.^{2} powder, and closed, like the Elswick ones, with a thin cork.

Friction. The Service friction vent-sealing tube, Mark II., is shown in section at Fig. III., and in parts by Fig. IV. on the opposite side of the plate. It is fired by a lanyard in the ordinary way, except that the pull-off is heavier than that of a tube; and as the travel of the friction-bar to the rear is very short, it has to be pulled with more of a jerk to avoid cutting the hand.

Description. The copper draw wire (*a*, Figs. III. and IV.) is 5½ ins. long from its insertion in the cone (*b*) to the end of the loop, and is of course straight though shown bent in Fig. III., for convenience in getting it into the plate. The loop at the end is formed by twisting the wire upon itself and slightly flattening it. A fine copper suspending wire

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(*c*) holds the last described wire in its usual position, and prevents accidental explosion. The cone (*b*) is of the same material as the body of the tube; at each end it is pierced with a tapped hole, leaving a small thickness of solid steel between them. Into one of these holes is screwed the draw wire, into the other the friction-bar. Two-tenths of an inch in rear of the ordinary position of this cone (Fig. III.) is a conical seating, into which it fits on discharge, and so effectively prevents the escape of any gas through the tube. The friction-bar (*d*) is roughed on all its faces, and screwed into the cone. Over the friction bar fit, first, two copper washers (*f*), which bear against the shoulder (*h*) in the body of the vent-sealer; then an oval copper tube (*e*), which, for convenience, is put on in two pieces. This bears against the copper washers, and between it and the friction-bar is the detonating composition, which is the same as that used in the quill friction-tube.

Action. When the lanyard is pulled, the suspending wire (*c*) is sheared, and the cone sets back in its seating: the friction-bar moves with it; but the copper tube surrounding the latter is held firm by the washers, and the friction thus set up fires the tube.

Electric Vent-sealer. The body of the electric vent-sealer is made of the same material as that of the frictional one, and is similar in shape to it, except that it is not provided with a shoulder. The insulated conducting wires (*a*, Figs. V. and VI.), about 18 inches long, terminate in two cylindrical coils (*b*) insulated on the outside but tinned inside, so as to form good conductors and a convenient method of attaching the "gun points." At the junction of the conducting wires with the head of the tube, they are further protected by frappings of oiled silk and twine. The cone (*c*) is in this case longitudinally divided into two, which are insulated from each other by a strip of asbestos paper (*d*), and from the body of the vent-sealer by an ebonite tube (*e*). Into each half of the cone, one of the conducting wires enters at the rear end, and from the front end proceed two short copper wires connected by the ordinary naval bridge, with an electrical resistance of 1·65ω, which is embedded in a priming of guncotton dust and mealed powder. To prevent any shifting of the half cones, by which the bridge might be broken, the wires supporting the bridge pass through two millboard washers (*f*), which secure them. The electrical action is so obvious that it appears unnecessary to describe it: any low tension firing apparatus will explode the tube.

External differences of patterns. The first pattern issued to H.M.S. "*Inflexible*" is shown in Fig. VII. There was no projection on the head except that for the suspending wire, and the extracting recess was a slot cut on one side of the head only. This slot, however, was soon extended all round the head, as shown in Fig. VIII. As this pattern occasionally got jammed, a large projection (*k*, Figs. III. to VI.) was introduced. This projection has one slit cut completely through it parallel to the axis, which causes it to act as a spring, and by fitting into a hole provided for it in the head to hold the tube in a truly central position. However, in the gun having the "de Bange" obturation there is no room for this projection nor for so great a length of draw-wire. Accordingly we find (Fig. VIII.) the wire projecting only about 1¼ inch, and as the loop has to be removed during manufacture it is formed of cast

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copper, screwed and afterwards soldered on to the wire. The electrical tubes for this gun are likewise without the projection (*k*).

Mark I. vent-sealers differed from those described, principally in being filled with loose powder and in other minor details. Mark I.

Two implements are supplied for use with these vent-sealers—an extractor and a rimer. The former is made of steel, and the other end is provided with claws to be used in moving the slide on the gun if necessary. The rimer is made of phosphor-bronze, so as not to injure the steel vent, and its function is to keep the latter perfectly clean, without which there can be no mechanical fit. Implements.

Various reasons have contributed to the reconsideration of vent obturation by means of a percussion tube. Among these may be mentioned the indifferent keeping qualities of all friction-tubes, which it is expected would be improved by the use of an ordinary percussion cap, the superior durability of which is well known, the greater facility with which a safety arrangement for preventing the firing of the gun before the breech is completely closed can be applied, and the smaller cost of the percussion tube. Percussion Vent-sealers

It is also the method of firing adopted by the French (Fig. IX.), who use a tube of copper having the end completely closed, but of such a thickness that a percussion cap inside can be readily fired by the blow of a hammer on the outside. The cap is held on an ordinary nipple screwed into the tube, which is filled with loose powder. This arrangement is obviously very simple and acts well; but, in order to extract the fired tube with facility, it is necessary to have a groove round the head for the extractor. But this weakens the head, and tubes so made, with the cap in the position of Fig. IX., were liable to fail, so the cap was moved down into the position shown in Fig. X., and as the thickness of metal over the cap was thus increased too much for the latter to be fired through it, a steel firing-pin (*a*, Fig. X.) has been provided, leaving, however, a certain thickness of solid metal (*b*) over the cap. In the course of experiments it has been found that brass is an unsuitable metal for the body of the tube, as it is liable to fusion by the heat of the powder gas; but that Delta metal, which is ordinary brass with the addition of a little iron and phosphorus, is sufficiently strong, will withstand the heat of the explosion, and, at the same time, is the cheapest of the metals employed for the purpose. French.

Besides the percussion vent-sealer mentioned above, the French have tried several frictional ones of much the same general shape and plan as our own, but usually provided with a wooden plug inside, through which the friction bar is drawn. Other foreign V.-S.

The Italians have adopted a pattern differing somewhat from those previously described (*see* Fig. IV., Pl. 2). It is screwed into the vent instead of being simply pushed into it. No doubt this should give more perfect obturation, and, though at first sight it would appear to lengthen the operation of loading, this objection will disappear in a gun provided with a detachable vent bolt; but until the contrary has been proved, the screw attachment would appear more likely to jam on the explosion of the charge and, consequently, more difficult of extraction than the parallel surfaces adopted by ourselves and the

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French. The travel of the friction-bar is about double that hitherto used in the Service pattern, and instead of a suspending wire, the point of the friction-bar (*b*) is turned down over a copper cylinder (*c*), which lines the friction tube. The detonating composition (*e*) is contained in the upper part of this cylinder, and is preserved from contact with it by a paper lining (*d*). The body of the tube is of some yellow metal, and is closed by a disc (*f*) of the same material. Besides closing the tube this disc would pierce the material of the cartridge and so open a passage for the flame to the powder. The Americans place a single shot in the bottom of their tubes for the same purpose.

Recent alterations.

The Service tubes have rather a heavy pull-off, and to lighten it, a longer travel for the draw-wire and the suppression of one of the copper cylinders surrounding the friction-bar have been suggested. The first would be attained by increasing the distance of the suspending wire from the cone by ·15-in., so that the total travel of the latter would become ·4-in., and it would gain some momentum before the copper washers were brought up by the shoulder in the tube. These alterations have been found to answer, and a tube so prepared will be issued as Mark III.

Experimental Electric.

In the guns which take the percussion tube, the Service pattern of the electric one is inadmissible on account of the wires which, coming from the centre of the head, are in the way of the lock. So a pattern is under trial which is shown on Pl. 2, in elevation at Fig. I., in plan at Fig. II., and in section at Fig. III. As copper-plated steel has not been found to be altogether a suitable material on account of its liability to galvanic action, Delta metal has been adopted in the present case. The insulated wires also have been much reduced in length, the whole of them being shown in Fig. I. The head of the vent-sealer has a groove like that in the head of a screw. The insulated wires being brought through the solid portion of the head (Fig. III.), are turned down in this groove, wound half round the head (Fig. I.) in a groove provided for the purpose, and twisted together as shown in the figure. Inside the tube the wires first pass through an asbestos wad (*b*, Fig. III.), and are then fastened into copper plugs, which are themselves embedded in an ebonite plug and connected by a platinum silver bridge (*e*) of the standard electrical resistance ($1{\cdot}65^{\omega}$) and length (·25-in.), but of the unusual shape shown in the figure, which is necessary to get that length of bridge into so confined a space without unduly diminishing the powder charge. The priming (*f*) is guncotton wool, the R.F.G. powder (*g*) is loose, and is protected from contact with the guncotton priming, or the closing wad, by discs of paper, and the tube is at present closed by a wad of beeswax. This tube is also much more cylindrical in form than the Service pattern, the conical form of which was adopted to ensure easy extraction, but is now believed to be unnecessary, and is found more difficult to load when the vent is slightly foul.

Of course many of these details, as for instance the loose powder and the beeswax wad, may be modified if the tube becomes adopted, and it will be distinguished from those already in the Service by a more advanced numeral, or possibly by a different name.

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VENT OBTURATORS.

Scale full size.

Fig I.

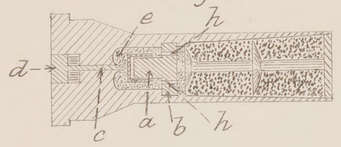

Fig II.

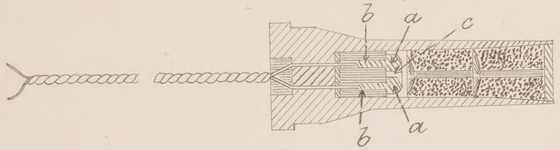

Fig III.

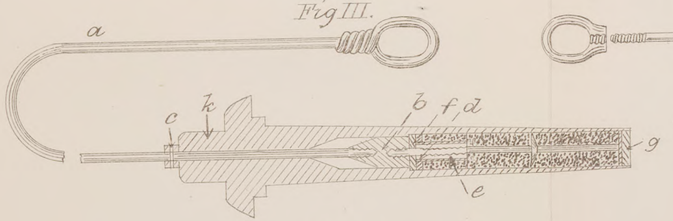

Fig V.

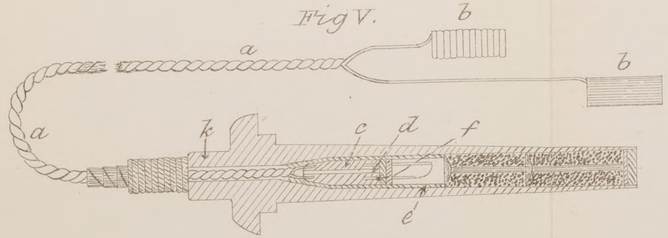

Fig VII.

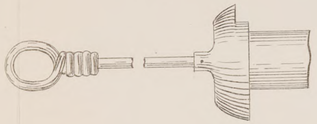

Fig VIII.

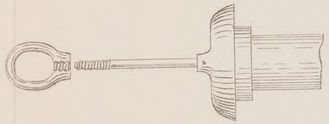

Fig IX.

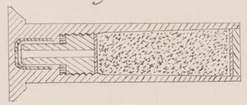

Fig X.

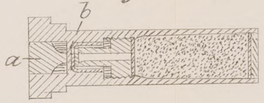

Fig IV.

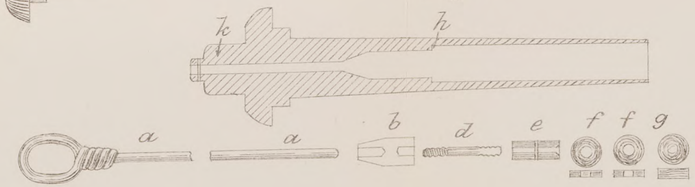

Fig VI.

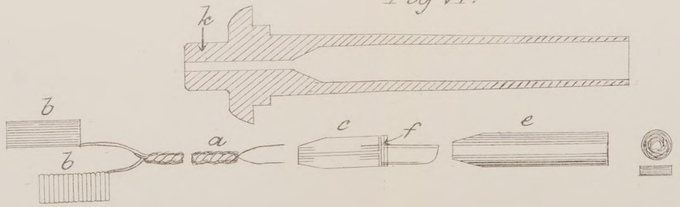

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PLATE II.

FIG I.

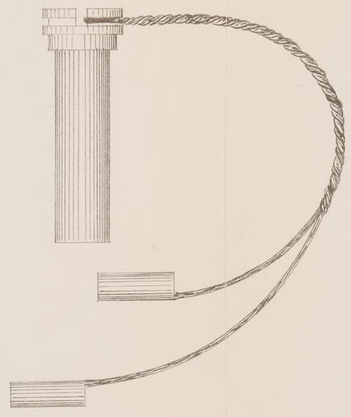
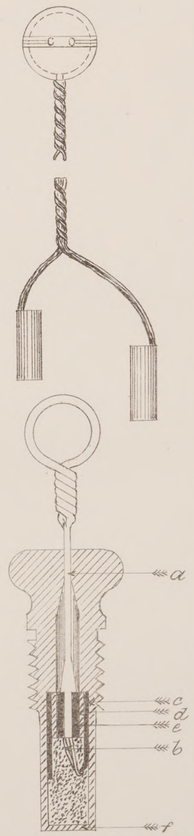


FIG II.



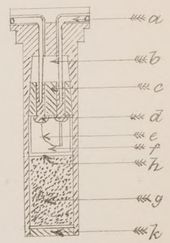


FIG III.

FIG IV.

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FIELD SKETCHING.

(*Re-printed from the Aide-Mémoire to the Military Sciences.—Vol. I., p. 533*).

"DUBLIN, 5TH JANUARY, 1846.

"Having been requested by the Editors of the 'Aide-Mémoire' to give a specimen of the sort of sketch of a position required during the Peninsular War, with an account of the mode of performing the work; the annexed, which I was required to make by his Grace the Duke of Wellington in Spain, is supplied accordingly; and the following is a statement of the circumstances under which that sketch was ordered, and the way I took to perform it.

"In 1812, when the French Army, under Marshal Marmont, was crossing the Tormes, at Huerta, above Salamanca, before the forts of that place were taken, the Duke—at that time standing on the high ground in front of Cabrerizos, observing the enemy—desired me to cross the river, and see what sort of a position there was in a certain assigned direction, for stopping the advance of the French, and to make a sketch of it as quickly as possible.

"There were about two miles to ride to the ford of Sta. Martha, and perceiving at once that that point would be the left of the position, on having crossed, I began at the point A.

A. "The lines of direction to B, C, D, E, F, G, were first laid down, sketching in the river, the roads, the village, and particularly the church of Sta. Martha. These lines of direction were, in fact, so many angles laid down and protracted on the sketch, but no instrument was used, as there was no time: everything was done by the eye. I did not dismount, and galloped from station to station.

C. "Having finished at A, I went along the road to Huerta (C), a farm of only two or three buildings, which was the only point to be seen in that direction from A; judging, then, this distance galloped over, the line from the church of Sta. Martha to C was assumed as the base.

"It was desirable that this front of the sketch towards Huerta should be done first, as the enemy's skirmishers were exchanging shots with ours between C and Pelobravo (M), when I reached that ground.

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"C being fixed, the lines to H, I, J, K, L, M, were laid off; the line H intersecting the line B, shewed where the rivulet joined the Tormes. The line J, intersecting A E, shewed nearly where the steep fall of ground at J would come. The line L pointed out where the road to Calvarosa Abaxo crossed the rivulet, and to that point (N) I went.

N. "Here the angle between Sta. Martha and C was laid off, which fixed N, and then intersecting the lines I and K (taken from C), those two farms were fixed. The direction (O) of the stream was noted, and also the line to J was intersected; also a fresh object (P), a remarkable tree, was taken, as it was the only object between J and P, along the crest of what would obviously be the position.

Q. "The village (M) could not be seen; I therefore went to the rising ground (Q) from whence it was visible; at this point it was observable that I was in a line with the farm (K) and Sta. Martha church; then, assuming that line to be correct, the angle between Sta. Martha and C was laid down, which thus fixed Q. The next angle was that between C and M, by which the village M was fixed.

P. "Proceeding from Q, up the hill, to P, the angle was taken formed by N and Sta. Martha, which fixed P; it was also noticed that the line to the farm (I) passed to the right of the farm (K), which observation helped to correct the sketch: also it could be seen that the line to H passed over K. The direction (J) was next taken, shewing the fall of ground and the direction of the road (D). There were no other points that could be fixed between D and the skirt of the wood (R).

R. "I then galloped to the top of the hill, and placing myself in a line with the two farms (I and K), that line was assumed to be correct; and then observing the angles between K and Sta. Martha, between K and C, and K and P, R was fixed.

"At R, I could see (over the trees) the village of Calvarosa Ariba, and also a chapel (called an Hermita) on the side of it, the directions to which were taken; also to the remarkable hill (S), and the abrupt slopes of the ground to the rear (U and V).

"A line was drawn to the fall, or gap, in the ground (T), taking great care that this, as well as those to S, Calvarosa, and the chapel, were as correct as possible in regard to the line from P, because the connection of the right of the position rested on this point, and the accuracy of the winding up of the sketch would depend on the correctness with which those angles were taken.

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T. "Next to T; and as, on reaching it, it was clear that none of the points on the left of the position could be seen, except R, it became necessary that the distance from R to T should be judged as accurately as possible—which distance became a fresh base. At T, thus fixed, all the right could be seen, and the Hermita could be intersected, as well as the ground to the rear (U, V, and E). The direction (X) of the smaller hill was taken, and the line over its summit, it was observed, passed to the abrupt right-hand slope of the ground (W), to the rear of the position. A farm also, in a hollow of some wood to the front, was also noted.

X. "I then went to the smaller hill, intending to go to the top, but the rocks were so rugged I could not ride up, so, standing on a line between it and T, at X, that station was fixed by observing the direction to E and to the Hermita.

"The line to Calvarosa from R was next intersected, which fixed that place. The direction to the houses (Z) was also laid down, and this place turned out to be the village of Arapiles; and the two remarkable hills were the celebrated hills of the same name.

"The line W being intersected, gave the boundary of the ground (Y): the farm in front, observed from T, could no longer be seen.

"Passing, then, down by the right and along the hollow between the two great hills, I went to the Hermita, and this point having been before fixed, from thence the direction of the further fall of the great hill (S) and two slopes of the hill on the further side of the Calvarosa valley were secured, as well as the direction of the water-course above and below. I then passed down the valley, and wound up the sketch at O.

"Going back from thence to C, I proceeded along the main road to D and E, putting in, on judgment, the village of Carvajosa, as well as the point F, where was a house, and where the great Salamanca road passed.

"I returned to Cabrerizos, finding the Duke where I had left him, and handed him the sketch, having been absent about two hours and a half. I made a verbal report to his Grace, pointing out the high hill (S), which we could plainly see from the spot where we then stood, observing that it was doubtful whether guns could be brought there, not having had time to ride thither. The Duke gave me back the sketch, to put it in ink, which I did, sitting down on the ground, and I returned it to his Grace.

"In the afternoon of that day the position just sketched was occupied by part of our army; and the enemy having, by

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signal, communicated with the forts of Salamanca re-crossed the Tormes at Huerta, and retired on the Douro.

"Some weeks after (July 21, 1812), this position was again occupied, but being too strong to be attacked in front, the French marched round it, and the battle of Salamanca took place next day, to the right of the ground here sketched—viz.: to the right of the village (z) of Arapiles.—P. B."

[NOTE.—The fact that the following sketch was made on active service, occasionally under fire, by the late Major-General P. Bainbrigge, Asst.-Qr.-Mr.-Gen., Ireland, while serving on the Staff of the Duke of Wellington in the Peninsula, is sufficient to justify its publication in the "Proceedings."—*H.W.L.H.*]

NOTE

ON

TRAJECTORIES.

BY

THE REV. F. BASHFORTH, B.D.

REFERRING to the "Note on Bashforth's Method of Working Trajectories," by Capt. MacMahon, R.A. (R. A. I. Proceedings, Vol. XII., p. 64), allow me to point out that a careful explanation of the difficulty may be found at pages 109–110 of my "Supplement to a Mathematical Treatise on the Motion of Projectiles, &c.," published in 1881.

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THE

ARMING OF THE PERSONNEL OF ARTILLERY.

BY

CAPTAIN R. F. JOHNSON, R.A.

As far as can be ascertained from the "Armed Strength" of the European Armies, the question has been decided in the following manner :—

	N.-C. Officers.	H.A. Gunners.	H.A. Drivers.	F.A. Gunners.	F.A. Drivers.
Austria.....	Cavalry sword and revolver.	...	...	Pioneer sword.[1]	Pioneer sword.
Belgium ...	Cavalry sword and pistol or revolver	Same as N.-C. Officers.	Same as N.-C. Officers.	An Infantry sword.	Same as N.-C. Officers.
Denmark ...	Sword and revolver	...	...	A sword.[2]	A sword.
France	Light Cavalry sword and revolver.	Same as N.-C. Officers.	Same as N.-C. Officers.	Carbine[3] and revolver.	Same as N.C. Officers.
Germany ...	Sword and pistol.	Same as N.-C. Officers.	Same as N.-C. Officers.	A side-arm[4] called a "fascine knife."	Same as N.C. Officers.
Italy	Cavalry sword and pistol.	...	...	Partly with carbine & sword-bayonet; partly with straight sword.	...
Russia	Long sword and revolver.	Same as N.-C. Officers.	Same as N.-C. Officers.	Short sword and revolver.	Same as gunners.
Spain.....	Sword.	...	...	Sword-bayonet.[5]	...
Sweden.....	Sword and revolver.	Same as N.-C. Officers.	Same as N.-C. Officers.	A sword.	Same as N.-C. Officers.

[1] A short, straight sword, 25 inches long (with hilt). [2] Lighter than that of the drivers.
[3] Carried slung. [4] Badeners, Yatagans; Bavarian troops, Chassepots. [5] 12 carbines per battery.

The various arms, above-mentioned, may be divided into the following classes :—

a. Offensive. Carbines and rifles.

b. Defensive. Swords and sword-bayonets.

c. Offensive-Defensive.[1] Pistols and revolvers.

[1] A rather offensive term.

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The *personnel* may be divided into five classes :—

1. Mounted N.-C. officers and gunners.
2. Gunners of Field Batteries.
3. Drivers of Horse and Field Batteries.
4. N.-C. officers and gunners of Garrison and Siege Batteries.
5. N.-C. officers, gunners and drivers of Ammunition Columns.

From the point of view, which appears the only correct one, that it is the business of Artillerymen to fight their guns until absolutely unable to do so longer, the first class of arms (the offensive) is entirely unsuited for all the classes of the *personnel* except the fifth.

In the Horse and Field Batteries we give 12 carbines per Battery, in the Garrison Batteries 1 per man.

The carbines, in the first instance, appear to be carried solely for sentry and guard duties; but if they are necessary for these, why do not Horse Artillery sentries mount with carbines instead of swords? The only other use for them is to shoot wounded and disabled horses; but a pistol carried with the Farrier's tools would serve equally well.

In the case of Garrison Artillerymen it may be useful to teach them the proper mode of handling the Infantry small-arm, just as Infantry are taught simple gun drill, but a few arms per Battery would suffice for this purpose, and rifles would be better than carbines. The fact of each man carrying a carbine and being inspected with it in his hand leads, in peace, to considerable time being devoted to training them in their use, and to the men being used for duties unconnected with their instruction in Artillery; a fact which cannot be lightly regarded, for the various kinds of ordnance mounted in our forts are numerous and the numbers of our "regular" Artillerymen are small. If forts had to be manned in large force, the mass of the men to fight them would have to be supplied by the Auxiliary Forces, and the few men of the 1st Brigades of our Regiment available for each gun would, to be of use, have to be thoroughly trained, to attain which the whole of their service "with the colours" is barely sufficient.

The Officers of Artillery, moreover, go through no course enabling them to give efficient instruction in the use of small-arms; and the amount of ammunition allowed for practice is very small.

For these reasons carbines and rifles, with the exception of a few for each Battery of Garrison Artillery, may be said to be useless and an unnecessary incumbrance as regards the first four classes of the *personnel*.

The second class of arms (the defensive) are suitable for all classes of the *personnel*, for the having something to defend one's self with on an emergency must give confidence, and the fact of bearing arms always engenders self-respect, a most important factor of military economy.

For N.-C. officers and mounted gunners it does not matter much whether the weapon is long or short, if it is well balanced and is

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carried so as not to interfere with the man's movements, whether he is mounted or dismounted. A good sword carried in a frog would fulfil all requirements.

For all classes of the *personnel*, except battery drivers (the third), whose case will be considered separately, the offensive-defensive class of arms represented by its latest development—the revolver—has exceptional merits. The revolver is just as effective at very close ranges (and it is only at these that the gun ceases to be the Artillery-man's sole legitimate weapon) as the carbine or rifle; it weighs about $\frac{1}{3}$th, and its ammunition is lighter and more compact. It can be easily and comfortably carried, requires much less room for its use, and can be used on guard duties for all the purposes of a carbine or rifle. If Cavalry succeeded to getting into a Battery, the gun detachments would be thoroughly covered from their attacks with "*armes blanches*" by the carriages and wheels, and could use their revolvers with deliberation; the effect of this kind of fire is vividly described in Tennison's "History of Cavalry."

The revolver should always be carried in a case on the waist-belt and have a long cord attached passing round the wearer's neck.

The question as regards the last two classes of the *personnel* is very different. To take them in order :—

The business of a battery driver is to manage his horses and to conduct his gun over the ground whatever it may be. The time when most care is required is exactly that when danger is most imminent and a man is most tempted to use the arms at his disposal, and is least likely to use them with discretion. For this reason all fire-arms whether offensive or only offensive-defensive are objectionable, as the owner of them is as likely to damage himself or his own side as the enemy. A revolver is difficult to fire straight even with deliberation; a driver with two horses to guide, holes in the ground to avoid, and a rough mount to stick on, might possibly shoot the man in front of him, or even one of his own horses, and in all cases must want the entire use of both his hands for the purpose of driving to the last moment.

Again, his short stature, and the harness, and the necessity of being always ready to mount and dismount, make it imperative that the weapon should be as short as it can be with efficiency. The present Artillery sword-bayonet is a well-balanced handy weapon, which seems to fulfil all requirements. A driver should be armed if only to give him the self-respect before-mentioned; but he only wants a weapon wherewith to defend himself against sudden assaults with *armes blanches*[1] for a few moments, until rescued by the gunners or other supporting troops.

There is one point connected with the armament of drivers which appears to have escaped notice, but which must on consideration strike anyone who has cut the sword exercise or watched military tournaments. A mounted man with any arm is powerless against an adversary in his left rear, and decidedly weak against one on his left

[1] It should be remembered that fire-arms are not in any case a defence against fire-arms.

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front. Therefore, if the arming of drivers is to be effective, those in the centre and lead must ride on the off horse, so as to have their sword-hand free. That this is simply a matter of a little practice is proved by the facility with which the off-pairs in 40-pr. gun teams are driven. It would at first appear awkward and strange to see the wheel driver on the near side and the others on the off, but it is only a matter of custom.

The change is not advocated in the case of the wheel driver, because—

(1). The change of material would be too considerable.

(2). The wheel driver has to make much use of his whip in guiding his hand-horse.

(3). The proximity of the limber wheel will protect him from attacks on his left rear.

If the sword-bayonet were carried in a frog, it would probably cause no inconvenience, but if it did it might be strapped on the front of the near side of the collar of the riding horse. It should have a good leather sword-knot to allow, in critical circumstances, of its being carried ready drawn hanging from the wrist.

The last class of the *personnel*—the gunners and drivers of Ammunition Columns—differ from the others in that the pace at which they move at is slow, and therefore weight is not so much a consideration, and because their escorts being kept as weak as possible they may be really wanted to defend the column in isolated situations. Each man might have a sword-bayonet and a rifle, the latter to be carried, as a rule, on the carriages, but slung on the back when danger is imminent, and all ranks, except drivers, a revolver in addition.

Summarily the armament indicated above is for—

1. N.-C. officers and mounted gunners. A sword carried in a frog, for use when mounted. A revolver for use dismounted.

2. Gunners of Field Batteries. A sword-bayonet carried in a frog, for defensive purposes. A revolver for use dismounted.

3. Drivers of Horse and Field Batteries. A sword-bayonet carried in a frog or otherwise, as is found most convenient.

4. N.-C. officers and gunners of Garrison Batteries. A sword-bayonet for defensive purposes; a revolver to use at close quarters and when accompanying storming columns.

5. N.-C. officers, drivers and gunners of Ammunition Columns. A sword-bayonet in a frog; a rifle carried on the wagon or slung on the back; N.-C. officers and gunners a revolver also.

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A PLAN
FOR ASSISTING THE MEMORY IN RETAINING THE SIGNS
OF THE
MORSE ALPHABET.

BY

MAJOR H. B. LAURENCE, Q.-M.-G.'s DEPT., BOMBAY.

COMMUNICATED BY

THE SECRETARY.

SIMPLE system of utilizing the Morse Alphabet like ordinary writing, intended for the use of Army Signallers, and others, who, having passed through a course are anxious to remember that which they have learnt, but who from various causes lack the means of constant practice, so essential for accurate signalling.

A person who has once learnt his own alphabet seldom forgets it, but this must be owing to the constant practice, otherwise take for instance the Hindi characters, thoroughly crammed up for some Examination but afterwards unused, and how long do we retain them in our memories?

Similarly a man goes through a Signalling Class, perhaps with credit; he finds the Morse Alphabet easy enough to learn, but for want of practice afterwards how easy to forget! My object then is to show an easy and amusing way of keeping it up, by constantly writing notes, memo.'s, post cards, &c. (This, I believe, with regard to post cards, is done by Telegraph employés among themselves for the sake of secrecy, but they use the ordinary symbols, which take up a lot of room). In every Regiment there are plenty of Signallers; let them scribble away amongst themselves. Small prizes might periodically be given to the man who could accurately and quickest make out, say, twenty lines of this writing, and hand it in, written in plain English letters.

The Morse Alphabet is formed by a combination of dots and dashes, and written in a line thus,

– —— ——– – – ——– – ——– – ——– – – – &c., &c.,

this takes up a lot of room, and unless the spaces between words

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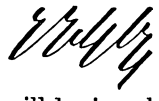
are very clearly defined leads to confusion. I propose, therefore, placing the dots and dashes one over the other, and joining the letters of each word as per plan marked A.

To write the word ARMY, which would be,

– —— – —— – —— —— —— – —— —— my plan is



the dots and dashes of each letter being carefully kept exactly under and commenced invariably at the right top; by this means the commencement of each letter will be in a level line and easy to distinguish.

The thin or "up strokes" count nothing, same as the flag in signalling, they are merely for convenience in writing, and to show termination of word.

For beginners ruled paper should be used.

As this little paper does not profess to teach signalling, but only how to practise the Morse Alphabet on paper, I will only add that in telegraphing with a key a dot equals one unit, and is depressed as long as it takes to count ONE, a dash as long as it takes to count THREE, a space equals the time the key takes to rise.

It will be observed that in watching a signaller with a flag at work, he goes through my writing "in the air," so in writing try and imagine your pen the flag, and your long and short strokes from right to left his waves.

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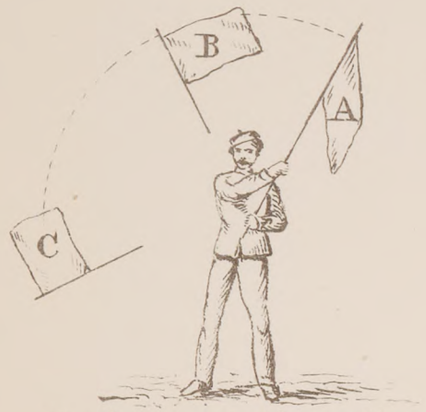
A



Position of Signaller

Wave flag from A to B and back to A one dot
" " " A " C " " " A " dash
After completion of message "order arms"

THE MORSE ALPHABET

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z CH

1. Altered position of Dots and Dashes for writing as seen in Flag Signalling.

2. Same in writing dots and dashes of each letter connected.

3 Same shewing mode of connecting letters.

GOD SAVE THE QUEEN

G O D S A V E T H E Q U E E N

In telegraphing pause between every two words 5 units. Thus =====

H.B. Laurence, Major.
Q.M.G. Dep.t

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MANŒUVRES

OF THE

XI. GERMAN ARMY CORPS,

SEPTEMBER, 1883.

BY

LIEUTENANT G. OSBORN, R.A.

THE XITH CORPS consists of three Divisions, not two, as do most of the others. A detailed statement of the Regiments, Batteries, &c., is given, with the towns and villages in which they were quartered during the Manœuvres:—

XI. ARMY CORPS.

General Commander: General of Cavalry, Freiherr von Schlotheim.

Chief of Staff: Colonel von Scherff.

21 DIVISION: Lieut.-General von Boehm.

41. Infantry Brigade: Major-General von Rauch.

1. Nassau Infantry Regiment, No. 87.
2. " " " No. 88.

42. Infantry Brigade: Major-General Freiherr von Ameluixen.

Hesse Fusilier Regiment, No. 80.
1. Hesse Infantry " No. 81.
Infantry Regiment, No. 97.

21. Cavalry Brigade: Major-General Freiherr von Gemmingen.

Rhenish Dragoon Regiment, No. 5.
1. Hesse Hussar Regiment, No. 13.

This Division was quartered in Homburg, Oberursel, Kirdhof, Ober-Eschbach, Bommersheim, and the villages around.

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22 Division: Lieut.-General von Unger.

43. Infantry Brigade: Major-General Fischer.
3. Hesse Infantry Regiment, No. 83.
6. Thuringen Infantry Regiment, No. 95.

44. Infantry Brigade: Major-General von Carnap-Quernheimb.
2. Thuringen Infantry Regiment, No. 32.
5. " " " No. 94.

22. Cavalry Brigade: Major-General von Bunting.
2. Hesse Hussar Regiment, No. 14.
Thuringen Ulan Regiment, No. 6.

The 22nd Division was quartered in Vilbel, Gross and Klein Karben, Windecken, and the surrounding villages.

25 (Grand Duchy of Hesse) Division: Lt.-Gen. Prince Henry of Hesse.

49. Infantry Brigade: Major-General von Grote.
1. Grand Duchy of Hesse Infantry (Body Guard) Regt., No. 115.
2. " " " Regiment, No. 116.

50. Infantry Brigade: Major-General von Uresson.
3. Grand Duchy of Hesse Infantry (Body Guard) Regt., No. 117.
4. " " " Regiment, No. 118.

25. Cavalry Brigade: Major-General von Radecke.
1. Grand Duchy of Hesse Dragoon Regt. (Gd. Dragns.), No. 23.
2. " " " " (Body "), No. 24.

This Division was quartered in Frankfurt, Offenbach, Bornheim, Rodelheim, and the surrounding villages.

Attached to XI. Corps.

11. Field Artillery Brigade: Colonel von Schell.
Hesse Field Artillery Regiment, No. 11.
Grand Duchy of Hesse Field Artillery Regiment, No. 25.
Nassau Field Artillery Regiment, No. 27.
Hesse Pioneer Battalion, No. 11.
Hesse Train Battalion, No. 11.

These were quartered in villages between Frankfurt and Homburg.

The Non-commissioned Officers' School (half Battalion) also took part in these Manœuvres, and were billetted in Oberursel.

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The troops were thus spread over a considerable area, and could easily be supplied with food, without any great strain on the inhabitants. Those not in barracks were allotted sleeping-places on straw in barns, stables, and all available accommodation in the cottages and houses of the villages. As one passed through every village, one saw on the farm-yard entrance, stable-yard door, or cottage door or inn, "5 men," "3 horses," "10 men," &c., as the case might be, and the Battery, Squadron or Regiment to which they belonged; for example, in Oberursel, a small country town, were billetted one Battalion 87 Regiment, the N.-C. Officer's School, and one Squadron 13 Hussars; in Bommersheim, a small village, 5 and 6 Batteries Field Artillery 27 Regiment, and 3 and 5 Companies 88 Infantry Regiment; in Bonames, a small village, 12 Company 115 Infantry Regiment, and part of the Train Battalion; in Vilbel were three Batteries Field Artillery 11 Regiment, part of 32 Regiment, and the staff of the 22nd Division.

The Battalions were about 550 strong, the Squadrons 112, and the Batteries 4 guns; the Horse Artillery had 6 guns each.

On the 21st, the troops from a distance commenced their march early, and arrived with those from nearer about 9 a.m. on the ground marked out for the parade, north-west of Nieder Eschbach. Here they were drawn up ready for inspection by the Emperor at 10 a.m. There was no salute. After the inspection, the Emperor with his staff and the foreign princes took up a position 300 yards from, and opposite to, the south-east of centre of the parade, where all the people were assembled. The Infantry marched past first in Company Column, then Cavalry in Squadrons, and Artillery in Batteries, lastly the Pioneer and Train Battalions. The Emperor himself marched past at the head of the Army Corps for 100 yards or so, wheeling to the right, and witnessing and criticising the march of the remainder. The step in marching past is different to our own: the knee is slightly bent, the instep braced up, and the toe pointed, the foot being then brought down smartly flat upon the ground.

On the 22nd, the Manœuvres of the whole XI. Army Corps against an enemy's Army Corps of two Divisions (marked out by a few Regiments, Batteries, and Cavalry) took place.

This first day of the German Manœuvres is for the purpose of teaching the men how to fight in large numbers, for the authorities to see how the troops are trained and behave, and for the General to practise manœuvring a large force. For this very open country is chosen. The other days are more especially for the commanders of smaller bodies, and for technical manœuvring in a more close country.

The general idea on the 22nd September was that a weak East Army had taken up the line Frankfurt and Main, when a West Army from Mainz and Darmstadt approaches. On the evening of the 21st September the foreposts stand as follows (supposed):—

West Army.—Soden, Rodelheim, Rockenheim, before Frankfurt and Offenbach.

East Army.—Ursel Bach, Escherheim, Seckbach, Mancur.

The East Army retires on the 22nd early, the right wing right of

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the Nidda River, and waits until the left has crossed at Vilbel and Nieder Dorfelden.

At 10 a.m. the East Army had its right wing in *ordre-de-bataille* (skeleton enemy) :—

4 Regiments of Cavalry, represented by 45 men from each Cavalry Regiment, before Ober-Eschbach.

1 Infantry Brigade, by 2 Battalions 87th Regiment in Ober-Eschbach, and on the heights above.

1 Infantry Brigade, by two Battalions 95th Regiment, between the former and Ober-Erlenbach, in reserve.

1 Infantry Brigade, by 1 Battalion 81st, and 1 Battalion 118th in Nieder-Eschbach, above it and half-way between it and Ober-Erlenbach.

1 Infantry Brigade, by 2nd and 3rd Battalions 81st, in Haarheim, above it, and in Companies in hollows on the plateau before Nieder-Erlenbach.

4 Batteries of Field Artillery, by 7/11, above Ober-Eschbach.

8 Batteries, by 4th and 5th/25, between Ober-Erlenbach and Nieder-Eschbach.

4 Batteries above Haarheim, by 8/11.

1 Cavalry Regiment before Nieder-Eschbach.

1 Cavalry Regiment before Haarheim.

The country is undulating in the neighbourhood, trees only being found around the villages, it otherwise being entirely open. The Esch-Bach and Erlen-Bach are only small streams. The valley of the Esch-Bach is from 200 to 500 yards wide, the northern slope to the plateau between it and the Erlen-Bach is somewhat abrupt. The plateau north of the Erlen-Bach is higher, and that south of the Esch-Bach lower and less abrupt.

The Cavalry of the West Army (the XI. Army Corps) bring in word at 10 a.m. that the enemy occupies the line of the Esch-Bach, south of Homburg. The Army Corps advance guards from each Division, consisting of 4 Squadrons, 2 Batteries, 2 Battalions, each advance in skirmishing order through Bommersheim, Kalbach, Bonames, and soon come under fire of the enemy's Artillery. The 21st Division are assembled by Ober-Ursel, the 22nd by Kalbach, and 25th by Bonames. The three Horse Artillery Batteries come into action on the high ground north of Bonames, and first concentrate their fire on Haarheim. The four Field Artillery Batteries of the 22nd Division concentrate their fire on Nieder-Eschbach; and those of the 21st against Ober-Eschbach. The Infantry gradually advance their skirmishing lines nearer to Ober-Eschbach and Haarheim, the 4 Regiments of Cavalry retired to the right flank by the Stein Muhle. The Infantry attack became continually fiercer before Haarheim and Ober-Eschbach, the villages being supported by the guns above them, and Ober-Eschbach by the eight Batteries also above to the north-east. The guns of the 25th Division now came into play against Haarheim and the guns above it, the Infantry gradually making a little advance against it; the deadly rattle of the rifles was incessant and terrific before this small village,

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the slopes towards which were perfectly void of cover, one could imagine a second Plevna or St. Privat was being enacted. These Infantry attacks on Haarheim and Ober-Eschbach began about 10·30; the firing at 11 o'clock on both flanks was very heavy, some of the 21st Division guns crossed to the hill north of Gonzenheim, and kept up a heavy fire against the enemy's right flank. Haarheim, however, was not strongly held for long, as the object was only to delay until the left had retreated over the Nidda; at 11.15 Haarheim was evacuated, and the enemy retreated up the hill under a heavy fire, which would have thinned their ranks terribly. The Infantry attack on Ober-Eschbach now became more determined, a strong firing line holding the crest of the hill and gradually advancing against it; the enemy held the houses, walls, and ditches in its front; by 11.35 Ober-Eschbach became untenable, as some of the Infantry of the 21st Division had come from Homburg into Gonzenheim, and occupied the hill to the north until Ober-Eschbach was nearly surrounded, and the Infantry retreated firing up the hill. The 21st Division came further round on the enemy's right flank, the two Regiments in reserve took up its defence, while the rest of the enemy's Infantry defended the position before Ober and Nieder-Erlenbach, the Artillery retiring and taking up positions on the hills overlooking the Erlen-Bach.

The Cavalry by Stein Muhle made a gallant charge against the Infantry and guns of the 21st Division, and thus enabled the Infantry on the right to retire to Ober-Erlenbach. The Infantry of the 22nd Division had in the meanwhile taken Nieder-Eschbach at 12 noon, and obliged the enemy to retire to the plateau; the Infantry of the 22nd and 25th Divisions soon gained the edge of the plateau above Nieder-Eschbach and Haarheim, but were received by a heavy fire on gaining it. Three Horse Artillery Batteries took up positions above Nieder-Eschbach, and several Field Batteries above Ober-Eschbach, and heavy firing continued all along the line; at 12.20, the Infantry began to advance from the edge of the plateau, and their supports, which were close behind on the slopes of the hill, soon followed them. Four Regiments of Cavalry, which had been waiting the opportunity by Haarheim, now advanced against the enemy's left flank. They were received by Infantry in squares firing volleys, the Corps Infantry advancing at the same time, and pouring in their fire on the retreating squares as the Cavalry retired; the Cavalry charged again, and again the Infantry formed squares, and retreated as the Cavalry retired. The Cavalry was about to make a final charge when the "cease-firing" was sounded.

After the "*Critique*" had been held by the Emperor, who was three hours on horseback during a heavy rain, the Commanders of Corps returned to their commands, and the troops marched back to where they were billetted.

On Sunday the troops rested.

On Monday, the 24th, two Divisions attacked one strong Division. This took up a position before Budesheim and Kaichen. The two

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Divisions at 10 a.m. were at Gross Karben, Klein Karben, Renden, and Neider-Dorfelden. They were assembled in the following "*ordre de bataille:*"—

Left Wing:—

41 Brigade..... { 87 Regiment.
88 Regiment.

Combined Brigade { 81 Regiment.
U. O. S. (N.-C. Officers' School).

Hussar Regiment 13.
Field Artillery, 3, 4, 5, 6, 7, 8 Batteries 27th Regiment.
Horse Battery 25th Regiment.
$1\frac{1}{2}$ Pioneer.

These were before Gross and Klein Karben.

Right Wing:—

25 Division {
- 49 Brigade { 115 Regiment. / 116 " / 117 "
- Dragoon Regiment 23 (4 Squadrons).
- " " 24 (4 ").
- Field Artillery, 2, 3, 4, 5, 6 Batteries 25 Regiment.

These were before Rendel.

Right side of Nidda under Dorfelden ... {
- 118 Regiment.
- 1 Squadron 23 Regiment.
- 1 " 24 "
- Field Artillery, 7th, 25th Regiment.

The enemy, somewhere between Rudesheim and Kaichen, had six Regiments of Infantry, three Cavalry, and eleven Batteries, and half a Pioneer Train:—

22 Division {
- 43 Brigade { 83 Regiment. / 95 "
- 44 Brigade { 32 " / 94 "
- Combined Brigade { 80 " / 97 "
- Field Artillery, 11 Regt., 1 Batty. 25 Regt., 1 Batty. 27 Regt.
- 1 Horse Artillery Battery 27 Regiment.
- Dragoon Regiment 5.
- Hussar " 14.
- Ulan " 6.

At 10 a.m. the Advance Guards, each of four Squadrons, two Batteries, two Battalions, advanced towards the high ground eastwards, and the Cavalry bring in word that the enemy occupies Marien Hof, the wood south of it to Budesheim, and the hills above it. The guns of the Advance Guard came into action immediately between the woods 'A' and 'C,' and on the right of 'C' opposite Budesheim, being answered by guns by Marien Hof and south of the wood 'B,' the enemy occupying this ridge running north and south. The remainder

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of the Artillery of the Left Wing soon came into action against Marien Hof and the wood to the south, the Infantry advancing a skirmishing line to the edges of the woods 'A' and 'C,' and concentrating most of their fire on 'B;' the wood immediately opposite Marien Hof was soon occupied by a strong firing line of Infantry. It was exceedingly hard for 'B' to be attacked, as the trees were large, and made the underwood at the edge appear very black, altogether concealing the position of the Infantry defending it, who could only be perceived by the slight smoke from their rifles, and the ground in front being without cover for an advance. At 11 a.m. the Infantry gradually advanced against 'B' from 'C' and the open, and closed on the corner of the wood 'B,' the enemy retiring firing, taking up all the cover available in the wood, keeping up a brisk fire from behind trees, bushes, and ditches, as they slowly withdrew through the wood. The noise of heavy Infantry fire amid the large timber of an old wood is very great echoing among the trees.

The seven Batteries of the Left had kept up a continuous fire against the wood and the guns and Infantry on the right, and against Marien Hof. The Cavalry remained sheltered by the woods 'A' and 'C' and in rear of the right, where the Artillery kept up a fierce cannonade against the enemy's centre and left, the Infantry gradually advancing against the high ground south of the wood and against Budesheim, the 118th with its one Battery advancing along the heights south of the Nidda.

At about 11.30, the Infantry advancing strongly from 'A,' and 'B' being occupied by our men, Marien Hof was evacuated, and the enemy gradually fell back fighting along its whole line, whilst our men gradually advanced. The enemy's position now extended from south of Kaichen to the bend of the river east of Budesheim. Some Cavalry and one Horse and one Field Battery being on our left, next to them a Regiment of Infantry, and on their right again five Field Batteries. The 6th and 14th Cavalry charged to give time from the enemy's right to form up nearer Heldenberg.

At 12.30 the enemy still held the plain half-way between Heldenberg and 'B,' with some Artillery firing salvoes half-way along the road to Kaichen, whilst some of their Artillery took up a position on the heights south of Windecken. The whole of the three Regiments of Cavalry now charged our left again repeatedly, and the enemy's Infantry on the right retired to Heldenberg and took up its defence, several Regiments being to the west and south of it; six Batteries had crossed to the south of the river.

The enemy were successfully retiring, though with heavy loss, to the south-west of Windecken when "cease fire" sounded. Their Artillery were taking up a position by the "Wartebaum," the tree still shown as growing near the spot where Napoleon I. commanded the Battle of Hanau, as a very good view of the surrounding country is gained from here.

After the "*Critique*" had been held, the combatants retired to their appointed bivouacks, the East Army near Windecken, the West Army on either side of the river near Nieder-Dorfelden and Ober-Dorfelden, having their outposts and picquets around their camps as in warfare,

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the Cavalry being to the front during the day, the Infantry during the night. After this two more days' Divisional Manœuvres took place.

The Germans park their guns in a line as we do; at the back of the guns six pickets are driven into the ground, marking out a rectangle behind every two guns, a rope is passed through rings at the heads of the pickets, which are about 2½ feet high, and each horse's collar is fastened by a chain to this rope. Other pickets are driven in in rear of each line of horses, and another rope passed round them, so as to enclose all the horses, to this outer rope heel ropes may be attached. Their men sleep in rear of the horses.

They cook their food in trenches, in much the same way as ourselves; but they have what a British soldier has never tasted. Their bivouac wine soup is delicious.

The *matériel* of the German Artillery is not so good as our own; but, it must be remembered, the horses' harness and men's clothing for manœuvres is the oldest they have; an entire new outfit is in store for every man and horse, which is issued at once on a declaration of war.

Though the Infantry were on their feet about fourteen hours a day, they were always cheerful and jolly, and ready for more, as many of their own Officers remarked.

The guns used by the Field Artillery in these Manœuvres were issued in 1873–4, and are certainly very good weapons, but not equal to our new 13-pr.

It may be remarked that in writing a description of Manœuvres over a large area of ground, it is well nigh impossible for one man to state accurately the position of every Regiment and Battery from his own observation.

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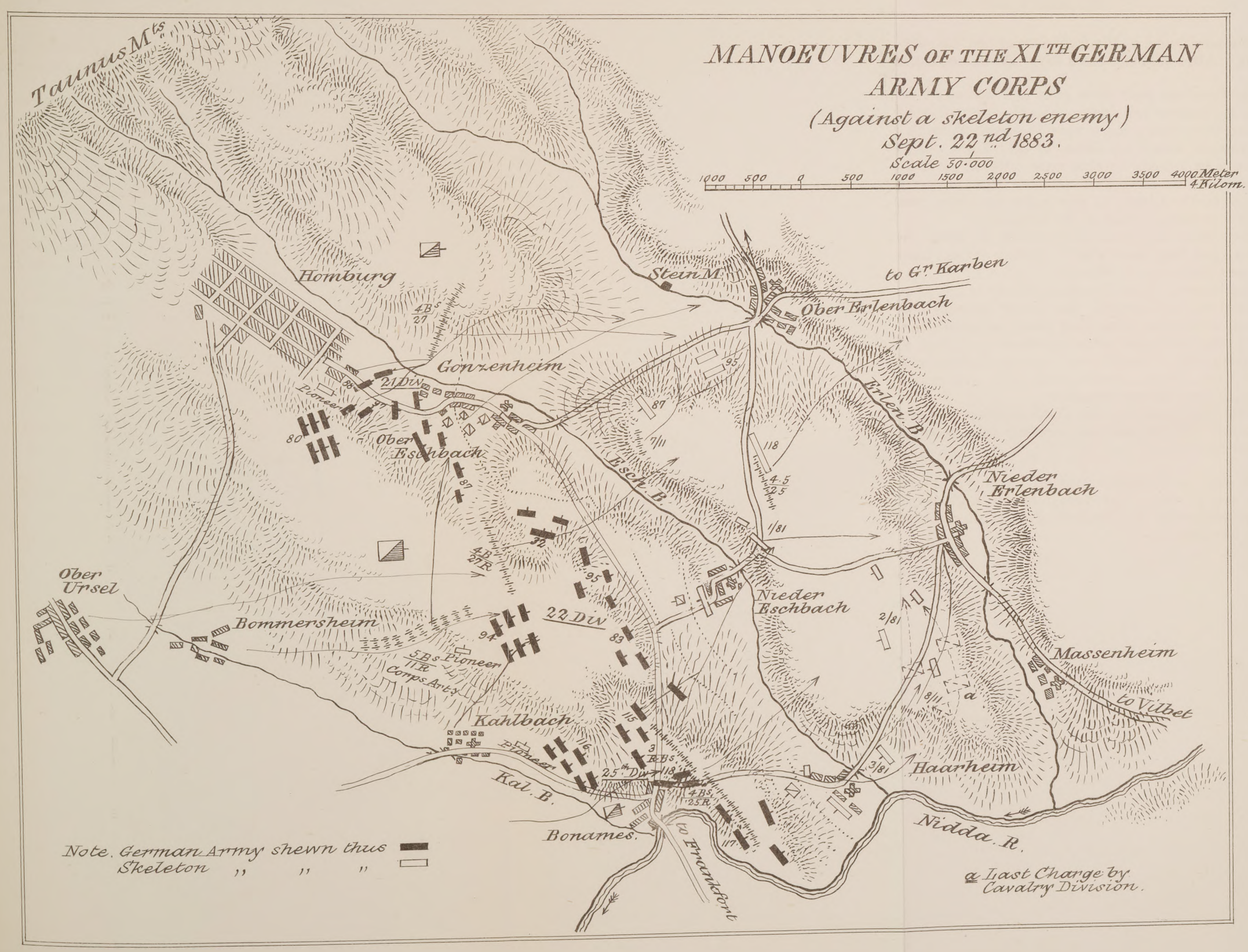
MANOEUVRES OF THE XITH GERMAN ARMY CORPS
(Against a skeleton enemy)
Sept. 22nd 1883.
Scale 1/50·000
1000 500 0 500 1000 1500 2000 2500 3000 3500 4000 Meter
4 Kilom.
Taunus Mts
Homburg
Stein M.
to Gr. Karben
Ober Erlenbach
Gonzenheim
21 Div
Pioneer
Ober Eschbach
Esch. B.
Erlen. B.
Nieder Erlenbach
Ober Ursel
Bommersheim
22 Div
Nieder Eschbach
Massenheim
to Vilbet
Corps Arty
Kahlbach
Pioneer
Kal. B.
Haarheim
Bonames.
to Frankfort
Nidda. R.
Note. German Army shewn thus
Skeleton " " "
a Last Charge by Cavalry Division.

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Burggräfern

Kaichen

Okarben

'A'

Marien Hof

Gr. Karben

Heldenbergen

'B'

'C'

Kl. Karben

Windecken

Rendel

Bodesheim

Wartebaum

R. Nidda

Kilianstädten

R. Nidder

Oberdorfelden

Niederdorfelden

Gronau

MANOEUVRES.
ON
24th " September.

Scale 1/50.000

1000 500 0 500 1000 1500 2000 2500 3000 3500 4000 Meter
4 Kilom.

Note. German Army shewn thus ▬
Skeleton - " - - - - " - - - " - - -

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NOTES

ON THE

TACTICS OF OUR SMALL WARS.

BY

LIEUT. C. E. CALLWELL, R.A.

THE revolution in Tactics—the natural result of the experiences of the breech-loader in 1866 and 1870—has given birth to a whole library of works on this subject, all expressing opinions almost identical and differing only in the various methods of treating the question. Most of the standard military literature of the day springs from German sources; the works of German authors are translated into English, and the views therein expressed are accepted readily and without dissent. Many of these writers have taken part in the gigantic struggles that a few years ago created the German empire; they depict war on its greatest scale—their unit is the Division—and they lay down to two places of decimals the number of men per yard of front in a battle when 200,000 are engaged aside. They, further, presuppose the opposing hosts to be similarly armed and organized, and assume operations to take place in civilized countries, where roads and railways offer every facility for rapid movements, and where requisitions lighten the strain on the communications to the rear.

The lessons to be drawn from these works are of no great value to us in our frequent contests with the savage tribes that in all parts of the globe border the British empire. Tactical formations learnt from bitter experience on the glacis slopes of St. Privat would have been entirely inapplicable to the scrimmage at Ahmed Kehl: the British formation at Ulundi has been almost unknown in Europe since the battle of Waterloo.

It is said, and it has been proved by ample modern experience, that in an attack the system of breaking down the enemy's resistance by penetration has now given way to the system of envelopment; such a rule cannot, however, apply when the defenders outnumber the assailants by five to one: it would be an anachronism to speak of massing guns in New Zealand or Ashanti. The pages of military

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history are full of instances of irregular warfare, where trained and disciplined armies, provided with all the necessary appliances for carrying on a deliberate campaign have been opposed, sometimes to guerillas fighting for liberty, sometimes to savages animated by mere thirst for blood. The most superficial study of these contests will show that Fortune does not by any means smile invariably on the side of the regular troops. Among the Alps of the Tyrol and the Sierras of Spain, the conquerors of Marengo and Austerlitz were kept at bay for months by undisciplined peasants; on the spurs of the great Snowy Range, Ghourkas met and defeated the seasoned veterans, who, under Lake and Wellesley, had overrun India from Fort William to the Punjab: the tide of Russian conquest, rising slowly, but surely, over the vast Steppes of Central Asia, till now it washes the walls of Samarcand and Bokhara, was rudely arrested by the Turcoman stronghold of Geok Tepe.

In the last five years British troops have been engaged in arduous campaigns in countries lying far apart, and differing from each other alike in their climate, in their physical features, and in their inhabitants, amid the rocks and gorges of Afghanistan, on the grassy undulations of South Africa, and on the desert of Egypt.

The Afghan war showed two distinct phases. One where ill-organized and cowardly levies, furnished with Artillery and Cavalry, were put forward to offer a feeble opposition, in previously selected and fortified positions, to the British advance. The other, where tribes stirred up by fanatical preachers, egged on alike by religious enthusiasm and by love of plunder, ill-armed, and without organization of any kind, boldly threw themselves on the invader in the open, with but little success it is true, but, nevertheless, on more than one occasion proving themselves foemen worthy of our steel.

In a contest against a civilized power, the Zulus, brave and warlike though they were, should have been overthrown with ease; yet they contrived to inflict on us a disastrous defeat. In both of these wars, however, England eventually obtained the mastery: Afghans and Zulus alike learned that, in a contest against civilization, inferior weapons and want of cohesion must eventually bring about their downfall.

Trained from infancy in the use of the rifle, inured to privations and hardship, but possessing sufficient education to estimate the immense value of discipline and organization in war, the Boers were in every respect a more formidable foe. From the massacre at Brunker Sprint to the disaster on Majuba Hill the campaign in Drackensberg was a mere succession of reverses. Our troops were overmatched throughout; outnumbered by an enemy infinitely their superior in the use of arms of precision, who, while possessing a mobility to which the most highly organized of European armies could never hope to aspire, was operating in a country eminently fitted for his peculiar mode of fighting, defeat was for them, under the circumstances, almost a foregone conclusion.

It is pleasant to turn from the unfortunate Boer war to the campaign lately brought to such a brilliant termination in Egypt. Here our

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large and well equipped force could have found but little difficulty in overthrowing Arabi's array of mercenaries and conscripts, had it not been for the assistance afforded them by railways and by skilfully placed entrenchments. The bold design of advancing to close quarters under cover of the darkness, robbed the Egyptians of the powerful aid of their fortifications; the sturdy attack of the Highland Brigade, and the bold advance of the Cavalry to Cairo did the rest.

If we consider the various actions fought in these campaigns, we find a great departure from the stereotyped forms of battle sketched out in modern works on Tactics. We notice but little of that preparation for attack by an overwhelming cannonade that is considered so essential; of the advance of the Infantry in successive waves, wearing down the obstinacy of the defence; of the feeding of the firing by supports, and the gradual merging of firing line supports and reserves into one mass that, when the crisis arrives, rushes into the hostile position.

Afghanistan.

Much of the fighting in Afghanistan was hill fighting pure and simple. At the Peiwar Kotel and at Charasiah the Afghans were gradually driven from positions that they had taken up on the crests of steep and rugged hills, by rushes of small bodies of Infantry. These advanced, often almost unsupported, firing when advantageous cover presented itself, and dashed into the "songas" and breastworks constructed by the enemy, who seldom awaited the charge. In both these actions the enemy was provided with artillery which, badly served, and without any means of retiring, was silenced without difficulty by our guns and fell into the hands of the Infantry. The dislike of Eastern races to the cold steel has been frequently shown in former wars. At Jezeen, when, in 1842, Akbar Khan made a determined effort to stay the advance of Pollock's avenging army, the Afghans are described as having stood up boldly, disdaining the shelter of their rocks, amid a perfect hail of bullets, but as having quailed before the bayonet. In the mutiny, charges by a mere handful of our Infantry frequently dissipated native hosts of twenty times their number.

At Ahmed Kehl the Afghans deliberately left a strong position and attacked our troops in the open. Sir Donald Stewart's Division, marching from Kandahar to Kabul, was advancing in a long column of route extending over six miles, when the enemy was found to be occupying some hills that barred the way, evidently bent on disputing the passage. The order of march was in two Brigades, each followed by its own baggage. The leading Brigade (General Hughes') formed up for attack; the baggage was halted, and the Artillery moved forward to prepare the way for the Infantry. Scarcely, however, had the guns come into action, when swarms of Afghans appeared on the crest of hills; in front, and on the left flank, masses of fanatical horsemen poured down on the small British force which, to meet the general direction of the attack, was obliged to form front to a flank.

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Between Hughes' Brigade and the troops in rear a gap occurred, of which the enemy failed to take advantage. Some hostile cavalry, however, under cover of broken ground, came unexpectedly on several native squadrons on the left, rolled them up, and were only checked by the Ghourkas in rallying squares. A most determined onslaught was made on our line; the guns fired case and reversed shrapnel, and some that were a little in advance were obliged to limber-up and come into action further in rear. The enemy, however, committed the fatal error of endeavouring to envelop the position instead of throwing themselves into the space between the Brigade that was formed up and the troops that were hurrying to the scene of action. Attacks on the right, no matter how successful, could only have had the effect of rolling up the line and hustling Hughes' Brigade back on that in rear, leading to a concentration of Stewart's force; while an attack on the left would have cut our army in half, and might have led to serious consequences.

At Ahmed Kehl, and in the severe fighting round Kabul that resulted in the temporary investment of the Sherpore cantonment, our troops were opposed to an armed and fanatical population, without guns, without leaders, and without self-reliance: at Maiwand, the Afghans fought under totally different conditions. Ayoub Khan had with him regular troops, horse, foot, and artillery, and was supported by a formidable body of the fanatical "Ghazis," who had fought so valiantly at Ahmed Kehl. The Afghan army, obscured by thick haze of a sultry Indian morning, was moving across the plain in a direction threatening General Burrow's communications with Kandahar; when, therefore, our force formed for battle, they formed to a flank as at Ahmed Kehl. For some hours the battle was a mere cannonade, Ayoub gradually unmasking his Batteries and pouring in a heavy concentrated fire, from which the Cavalry suffered considerable loss, but the Infantry, by lying down, were less affected. The vital point in the British line was the right flank. An attack on the left would, if successful, have driven our force back on the villages spoken of above, and towards Kandahar; if, however, the right flank were turned the line of retreat was severed, with the probable consequence of annihilation, unless a successful action should be afterwards fought, each army facing to its proper rear. After an ominous pause of some minutes, a dense mass of Ghazis swept down on the centre and left of Burrow's position; the Native Infantry on the extreme left gave way before the impetuous onslaught, were rolled back on the guns in the centre, two of which were captured in the rush. The right, where the 66th were posted, exposed by the collapse of the remainder to an attack in rear, retreated fighting, at first in a direction somewhat apart from that taken by the guns and Cavalry. The line of retreat being open, and the Afghan pursuit ceasing after a few miles, the remnants of the British force reached Kandahar in safety.

In this battle the Infantry fought in line as at Ahmed Kehl; the guns, after the commencement, were massed in the centre; the Cavalry was on the left or exposed flank; the baggage was in rear and, having retreated before the "Ghazi" attack had thrown the line into confusion, was for the most part saved.

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The attack and defence of a position is well illustrated by the battle before Kandahar some weeks later.

Ayoub Khan, abandoning the investment of the city on the approach of Roberts' force, took up a strong position on a ridge; his left in the difficult pass of Babi Wali, his right resting on the village of Pie Paimal at the termination of the ridge. In front of the right the villages of Gunda and Gaudigan were held in strength as advanced posts; these villages were about 1000 yards in front of Pie Paimal. Gaudigan on the right was just such an advanced post as is generally considered the best pivot for the flank of a position to rest on, guarding the ground over which the assailant was obliged to march in an attempt to turn that flank; the village would, however, have been of greater value to the defence had it been further in advance and more in extension of the right. The great objection to advanced posts is that the retreat of the defenders demoralises the main line of defence in rear; they also scatter the strength of the defenders and are liable to be enveloped.

General Roberts attacked the two villages simultaneously, and both were captured after some heavy fighting. The ground in rear, cut up by woods and orchards, was intersected by canals, the water supply of which having been cut in the hopes of injuring the Kandahar garrison, afforded covered approaches for the advance of our troops. Pie Paimel having been captured, the position was turned on the right; and the enemy, utterly defeated, fled in haste, leaving their camp and their guns to be captured. The direction of their retreat prevented the Cavalry, who were on the British left, from completely dispersing them, while that on the British right failed to advance till the time for effective action was past.

General Roberts nearly always attacked the Afghans in flank. At the Peiwar Kotal, the greater part of the force made a long detour under cover of night and fell on the left of the hostile position in the early morning. As soon as this flank attack had made itself felt, the remainder of the troops attacked in front, and the victory was completed by a further turning movement by the force on the flank, which was under the General's personal command.

At Charasiab, also, the hostile right flank was attacked; but an attack on the centre was pushed well home at the same time. At Kandahar only a small force was left to threaten the enemy's left and centre, two of the Infantry Brigades attacked the villages spoken of above, while the third was in support.

The attack and defence of villages was well exemplified on several occasions in this campaign. Afghan villages are, as a rule, admirably adapted for defence; the mud walls, hardened by age till they resemble concrete, resist field artillery fire; there are no splinters, the shells generally passing through the front walls and their fragments being absorbed in the small rooms inside. Moreover, one of the great disadvantages under which trained troops engaged in the defence of villages labour, namely, the dispersion of the men and the difficulty of supervision, does not affect warriors like Afghans, when each man fights for himself.

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The disastrous sortie from Kandahar is an instance of an unsuccessful attack on a village. Deh Khoja, at a distance of about 1000 yards from the city wall, was attacked by a force of 800 Infantry, after a preliminary bombardment by two 40-prs. and two howitzers of half-an-hour's duration. The attacking force was broken up into three parties. Some Cavalry, making a long detour, arrived on the far side of the village from Kandahar, where they impeded the advance of hostile reinforcements to a certain extent. The assailants, on arriving at the village, found every door barricaded and every wall loop-holed; with great difficulty they succeeded in establishing themselves in some houses in rear, but, finding their position untenable, and swarms of the enemy arriving from all sides, they were obliged to fall back across the open to Kandahar, suffering heavy losses. The Cavalry did good service in covering the retreat. There was, practically, no Artillery preparation for this attack, which took place in the early morning, and was intended as a surprise. In attacking a village the difficulty, as a rule, is to gain a footing; once in, attackers and defenders fight on equal terms, and it is presumed that the former have the advantage of superiority in numbers. At Deh Khoja, General Brooke did gain a footing, but, the enemy being enabled to bring reinforcements to the spot, the endeavour to keep what had been won only resulted in our suffering far greater losses than had the attack failed entirely at the outset.

The ferocious instincts of the savage often suggest to him the treacherous device of simulating death, with a view to springing on his enemy unawares. Wounded Afghans frequently attacked our soldiers, sometimes even when these were ministering to their wants; this practice led to stern reprisals on the part of our native troops. The same thing occurred at Tel-el-Kebir, and our men were with some difficulty restrained from slaughtering the wounded and prisoners in consequence. Of late years, however, there has been no instance of such a ruse being successful beyond killing a few individuals. At Assaye some Mahrattas, left by our men for dead, seized the guns captured from them a few minutes before, turned them on the assailants, who were eagerly pressing the pursuit, and rendered their position for a moment somewhat critical.

In European warfare, opposing Generals have too little control over the huge armies under their command to be able to employ with success the strategem of feigning retirement, with a view to drawing an enemy out of a strong position and attacking him at a disadvantage. This device, by which it is said that William the Conqueror won the battle of Hastings, has on more than one occasion been used by us with brilliant results in our Indian wars, notably at Delhi, in 1803, where Lord Lake by this means achieved a decisive victory with inferior forces over an enemy in a strong position. In the second Nepaul war, a small reconnoitring party, having advanced some distance from one of our camps, came on several hundred of the enemy on the outskirts of a wood; by retiring slowly and sending back information they succeeded in luring them from their position till, attacked by our whole force unexpectedly,

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they were so roughly handled that the Nepaulese abandoned the whole of the Terai.

In the early part of the Afghan war, General Gough, with a Brigade of all Arms, came, near Futteabad, upon a large gathering of hill-men, amounting to several thousands; these were drawn up in a strong position covered with breastworks, each flank resting on a steep declivity, and they completely commanded the road to Gundamuk. The Cavalry and Horse Artillery were sent to the front, and the latter came into action at short range. The guns were then retired by alternate half batteries, covered by the Cavalry, till, by the time that the Infantry had arrived on the ground, the enemy had advanced well out of their position. A skilfully arranged attack followed and, the three Arms working well together, the action resulted in a complete success, the enemy being dispersed and suffering heavy losses.

In a skirmish near Kandahar a squadron of Native Cavalry greatly distinguished itself; by retiring and then wheeling about unexpectedly and charging home, they inflicted great damage on a very superior hostile force; and this manœuvre was repeated several times with equal success.

The broken and rocky nature of the country was in this war the principal cause of Infantry so frequently pushing so far in advance quite unsupported; "songas" and breastworks were met with unexpectedly, these had to be carried at once or else the ground already gained was untenable. Moreover, officers and men alike were thoroughly imbued with the feeling that Easterns', once on the move, must be kept on the move, at all hazards. At the battle of Kandahar, after the capture of Pie Paimal, White, of the 92nd, found himself with a mere handful of men face to face with several thousands of the enemy, apparently intending a counter-attack. Hostile reinforcements were hurrying up, and there was not a moment to lose. Nothing daunted by the formidable nature of the task, the Highlanders and Ghourkas threw themselves into the very heart of this mass which, completely taken aback by the daring attack, broke and fled, all further resistance ceasing at once.

In the great rising of the tribes round Kabul that led, after severe fighting, to the retirement of General Roberts' force into the Sherpore cantonment, the complete want of control of the leaders over the turbulent host they had succeeded in bringing into the field was of great importance to us. While 60,000 men surrounded the British force in the walled cantonment, an assault of which, even allowing for the inadequate garrison, must have cost them very dear, General Gough's Brigade was allowed to advance almost unopposed through difficult defiles and over lofty Kotals, till his appearance near Kabul, coupled with the failure of their half-hearted attack on Sherpore, led to the dissipation of this, the most formidable combination to which our armies were opposed during the entire war. A few days previously, when Roberts' Brigades were somewhat scattered and Sherpore was almost defenceless, the opportunity was allowed to pass, and the masses of Afghans that had collected from all parts of the country to annihilate the hated "Feringhee," seduced by the hope of plunder,

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turned aside to loot the city. If we turn from Afghanistan to S. Africa, we see at once that, though inferior to the Afghans in civilization, the Zulus, as regards discipline, are infinitely their superiors; these were always well in hand, had confidence in their leaders, and performed what manœuvres were required with precision.

The Zulu War.

While in Afghanistan the fighting was for the most part of a guerilla nature, the Zulu war was undertaken against regular armies under leaders experienced in savage warfare, their supreme direction being in the hands of Ketchwayo. The Zulus possessed fire-arms, but were entirely ignorant of their proper use, being unable to understand the sighting; their principal weapon was the assegai, which they wielded with fatal skill; Cavalry and Artillery they had none, their true strength lying in their vast numbers, in their reckless courage, and in the mobility of the huge armies they were able to put in the field. The tactics employed by the Zulus against our small forces were simple; their object being, by first outflanking and then surrounding their seemingly insignificant foe, to overwhelm him by sheer weight of numbers. Although they possessed no Cavalry, their remarkable fleetness of foot to some extent compensated for the deficiency; over rough ground, indeed, they could move on foot as fast as horsemen. During the flight from Isandlwhana to the Tugela, many men on horseback were overtaken and assegaied. Their extraordinary rapidity in advancing to an attack is one of the most remarkable features of Zulu warfare, and this circumstance exercised a considerable moral effect on our troops.

The Boers, natural enemies as they are of the Zulus, have had many hard tussels with these dusky warriors; in the early part of the century their farms were often pillaged and the inmates massacred during incursions of marauders over the Tugela into Natal. Experience, however, proved to them that, fighting behind walls or when inside a "laager" of wagons, they had little to fear, however great the odds that were against them, as regards numbers.

Having undertaken the invasion of Zululand, our armies were obliged to assume the offensive strategically; that this was perfectly compatible with defensive tactics was clearly demonstrated at Ginghilovo and Ulundi.

The only admissible formation for encountering enemies such as these, who advance in masses to close quarters, is one that will combine a maximum of fire effect with sufficient solidity to give confidence to the soldiery; the men must fight shoulder to shoulder, and, as the Zulus attack was always enveloping, the square, against which all their efforts proved unavailing at Ulundi, was undoubtedly the proper method of defeating their onslaught in the open. At Ulundi the Infantry forming the sides of the square, or rather oblong, were in two-deep line, guns or gatlings were placed at the corners and in the centre of the sides, the Cavalry was in the middle till required. The square was formed immediately after crossing a river that had, by

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tacit consent, formed a boundary between the forces for some days, and in this formation the army moved some distance: the ground was open, so that no confusion occurred in this advance, but in difficult country a movement of the kind would have been well nigh impossible. It will be remembered that during the Russian retreat on Moscow, in 1812, Murat, with 20,000 Cavalry, overtook their rear guard near Krasnoi, consisting of 5000 Infantry and some Squadrons of Cavalry. The Russian Cavalry was swept aside, but the Infantry, forming in one great square, and retreating in this formation, repulsed the French attacks, till, gaining some ground impassable for Cavalry, they were enabled to resume the former order of march in safety.

At Isandlwhana, as soon as the enemy was descried advancing on one flank of the camp, the troops were turned out and sent to meet the impending attack. Eventually the British line extended about 2000 yards. The Frontier Horse, on the extreme right, retreated fighting, inflicting considerable loss on the Zulus, having been pushed out in the first instance to a distance of three miles from the camp; the Rocket Battery was surprised by some Zulus creeping up a ravine and was captured in this part of the field. While the mounted men thus engaged the left horn of the Zulu army, the right horn sidled round the Companies of the 24th on the left of the line, outflanking our troops and making for the rear of the camp. The Infantry were in extended order, their fire making but little impression on the Zulus, who now advanced on all sides. The Native Contingent in the centre broke, and through the gap thus formed the enemy poured in, making for the camp. The Companies on the left had no time to rally nor even to fix bayonets; they were cut off to a man: the guns had limbered-up and retired through the camp, but were stopped by a ravine and fell into the hands of the enemy. Some desperate fighting took place on the right and in the camp, but the troops being completely broken up success was impossible and, the line of retreat being cut, the soldiers stood their ground in groups and sold their lives dear. The Zulu army on this occasion amounted to 14,000 men of whom 10,000 attacked; the British force little exceeded 1000 men.

The same evening a force of 4000 Zulus advanced against the post at Rorke's Drift, which was garrisoned by a mixed force of 140 men, of whom about 40 were sick. From behind a breastwork hastily constructed of mealie bags, this small band kept the Zulus at bay throughout the night; and, although the gallant defenders were driven within the inner entrenchment, the enemy finally withdrew after suffering heavily.

At Isandlwhana there was ample time and abundance of wagons to form an entrenched laager, even while the hostile army was advancing, and there seems to be no reason for supposing that under the circumstances the Zulu attack should have been any more successful than at Ginghilovo. The formidable nature of the enemy with whom our troops had to deal had not been recognized; it was supposed that tactics that had often proved successful in Kaffirland would prove equally so against the Zulus; and the only fear, indeed, seems to have been that the enemy would decline to give battle.

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The laager at Ginghilovo was surrounded by a trench, the wagons forming a retrenchment, inside of which the cattle were placed; the site was on the summit of a slight knoll. The laager was little more than 130 yards square, and the British force amounted to over 5000 men. At Kambula the small British column was in a strong defensible position; a redoubt had been constructed, and near this was a wagon laager, and there was besides this a smaller cattle laager, which the Zulus captured and held for a time. The Zulu skirmishers in both these battles inflicted considerable loss on our men with fire from their Martini-Henry rifles, which they had taken at Isandlwhana and the Tutanli river.

The gatlings are said to have been very effective both at Ulundi and Ginghilovo; indeed they could hardly fail to be so. In the former action, however, they got out of order during the fight.

The solid formations employed in latter phases of the war were, of course, open to the objection that while the fire on one side was divergent, that on the side of the enemy was convergent; but the want of skill in the use of their fire-arms, on the part of the Zulus, rendered this a less serious objection than would appear at first sight.

At Kambula, we see a remarkable instance of an enemy being skilfully drawn into a premature attack. A few mounted riflemen, under Colonel Buller, rode out from the camp and opened fire on the right horn of the Zulu army, which, unable to withstand the temptation, rushed forward to overwhelm this insignificant force. The mounted men retired firing, and drew the Zulus up to within 300 yards of the camp, when they were checked by a withering fire from the Infantry inside the laager. The hostile attack was thus precipitated and, to a certain extent, thrown into confusion.

At the commencement of the Zulu war, there was no regular Cavalry with the British force; the mounted irregulars, however, did good service in scouting and reconnoitring, and committed great execution after the failure of the attacks on Kambula and Ginghilovo. After Kambula the horsemen turned the retreat into a route, stabbing many of them with their own assegais: the pursuit was only stopped by darkness. Early information of the approach of the Zulus was brought before Ginghilovo, but the open nature of the country often rendered scouts almost unnecessary.

Nothing is more remarkable in both these wars than the frequency with which hostile masses were able to assemble in the immediate neighbourhood of our armies undiscovered. At Isandlwhana the Zulus, arriving in small detachments, collected in a valley only five miles from our position on the night before the disaster; an advance against the British camp had not been intended till the day following: the attack was brought on by a few mounted men, who had been sent out and who opened fire on the Zulus before they were aware of the vast numbers they were engaging. The sudden arrival of a large army from Ulundi, while the fighting was going on on the Inhlobama mountain, must have led to the annihilation of Buller's forces on the summit, had not the Zulus been too exhausted to close on our troops. This army was descried when five miles off, but advanced

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with extraordinary rapidity. In the Chardeh valley, General Massy came quite unexpectedly on a mass of Afghans making for Kabul, and in the action that ensued the guns were lost and the Cavalry decimated. Before Maiwand Ayoub's force had not been thought dangerous, although in the bazaars of Kandahar his true strength was well known. In Afghanistan the Political Officers professed to have a thorough knowledge of all that was going forward beyond our outposts; but their information, from whatever causes, was invariably incorrect.

The Boer War.

The outbreak of the Transvaal rebellion was a complete surprise, even to those best capable of judging the true feeling of the Boers. That they were dissatisfied with the British rule that had been forced on them was an acknowledged fact, but the general opinion throughout S. Africa up to the actual commencement of hostilities was that they would submit to what appeared at the time to be the inevitable, and that they would not venture to commit themselves to any decided action. Even after the small British garrisons, scattered about the Transvaal, had been beleaguered, and the 94th Regiment had been shot down in cold blood at Bronker Sprint, the authorities still failed to grasp the full extent of the danger.

The position taken up by the Boers at Laing's Nek, was one of extraordinary strength. A semicircular ridge stretches across the road from Natal to Pretoria, about 300 feet in elevation at the central point, where the track passes through a slight dip; on the right the ridge rises, at first gradually, afterwards abruptly, forming Majuba mountain; at some distance on the left a spur juts out terminating in a small conical hill, which formed the extreme left of the Boer position. The inclinations generally are steep, except in the centre when the road ascends a glacis slope. From the command of the Boer position it was impossible to estimate their strength or to ascertain their dispositions; and Colley's force, every movement of which was visible to the enemy, was therefore working somewhat in the dark. The General's plan of attack was briefly this: it was seen that, owing to the rounded conformation of the slopes in the left centre, an advance could be made some distance up, under cover from the enemy overhead, although exposed to enfilade and reverse fire from the left. Colley determined to assault the position at this point with his Infantry, while an attack was to be made at the same time by some Mounted Infantry on the conical hill on the left. This second attack was, through some mistake, made prematurely, and turned out a complete failure; the Infantry, although exposed to a heavy flanking fire, pushed on till, within a few yards of the crest, they became exposed to a withering fire in front, the Boers having collected from all sides as soon as the attack became apparent, and were repulsed with great loss.

Before this action, the fighting qualities of the Boers had been held in the lowest estimation; they had not proved themselves a very

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formidable enemy at Boemplaats; their successes over native tribes had been gained by their superior weapons and not by their courage. The attack was made in complete ignorance of the strength of the enemy; even had the attempt on the conical hill been better timed, and had it been perfectly successful, it is more than doubtful if the Infantry could have gained a footing. The position had been shelled previous to the assault, but, as the ground occupied by the Boers fell rapidly to the rear, the slope did not conform to the trajectory of the projectiles, and these did little damage; the Artillery however did good service in covering the retreat of the Infantry. The British force numbered about 1000, half of which was in reserve; the strength of the enemy was probably considerably less.

Emboldened by success, and reinforced by numbers who had at first held back, the Boers commenced making raids considerable distances into Natal, cut Colley's communications, and almost besieged him in his camp. After some days of inaction, the General, with a view of restoring his communications, moved out with a force of about 400 Infantry and with two guns, endeavouring to traverse the hilly and broken country between the camp and Newcastle. No sooner had these left the camp than the Boers—occupying Laing's Nek, who, from these points of observation, were kept acquainted with every movement of our troops—mounting their ponies, moved round over the hills to intercept them. In this design the enemy were perfectly successful; an action ensued in which our side suffered great loss, and only escaped capture by accident. The position occupied by Colley, on finding the way barred, was singularly unfortunate; a low round hill, fringed below with rocks that gave perfect cover to the enemy within 300 yards of the crest, where our men were posted on the sky-line, with the lower slopes falling rapidly, and sheltering the hostile reserves. The Boers contented themselves with forming a ring round the position and firing on the guns and Infantry from behind the rocks. Fortunately the rounded conformation of the ground prevented the Boer fire from taking our men in reverse, otherwise the losses must have been greater, but the guns were an easy target for the Boer marksmen, and were reduced to silence: not, however, till the detachments were practically annihilated. The darkness put an end to the fight, and during the night the British force succeeded in withdrawing from the hill, and arrived safely at the camp with the guns, but the wounded and an Artillery wagon were left on the ground.

In the Ingogo affair we have a remarkable instance of the employment of Mounted Infantry. The Boers are perfect Mounted Riflemen, their mounts are trained to stand while the riders dismount to fire, and being small are easily mounted again, should necessity arise for a change of ground; accustomed to rough life on the Veldt, the wants of man and horse alike are easily satisfied. They can thus move rapidly over considerable distances unhindered by transport difficulties, and arriving unexpectedly on the scene of action, lend to their attack the moral effect of surprise. While Colley's small force, encumbered with Artillery, toiled slowly a few miles along the heavy track towards Newcastle, the Boers came down from all sides, and caught the British

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General in a trap, some of their number having travelled over twenty miles to the field of battle.

It is very doubtful if troops occupying an isolated hill are in a favorable position for defence; being on the sky-line they afford an excellent mark for those below; if the slopes are steep and broken the assailants can creep up unseen, and, in any case, retreat from such a point must be a difficult and dangerous operation. The Takht-i-Shah, towering above Kabul, although held by crowds of fanatics, was assaulted and cleared by MacPherson's Brigade in a few hours and with little loss. The storming of Sekukuni's "Fighting Koppie" was rendered difficult, more by cover afforded to the natives by caves and holes among the rocks, than by the command of the position. The occupation of the Inhlobam Mountain by mounted irregulars a few days before Kambula ended in a most hazardous retreat, disaster being averted only by the gallant bearing and personal exertions of those in command.

The conformation of the hills in South Africa is very singular. Like the celebrated Table Mountain, they are flat-topped, with sides broken and precipitous, these are often covered with boulders and bushes, and are sometimes almost inaccessible. The Inhlobam and Majuba Mountains both present these features. The latter rises to a height of about 800 feet above the right of the Boer position across Laing's Nek, the elevation above the surrounding country being considerably greater; the circumference at the summit is about 300 yards, the slopes on all sides being almost precipitous. With what object this commanding point was occupied by Sir George Colley is uncertain, the insignificant force of 500 men that climbed up during the night, and found themselves at daybreak with the hostile position spread out at their feet like a map, was insufficient to effect anything beyond indirectly supporting a general frontal attack on the Nek, for the execution of which, if ever intended, there were no troops actually on the spot. As it was, the Boers, recovering from the momentary panic that set in when our men were descried on the mountain, deliberately set about driving off the intruders, while picked marksmen prevented our men from showing on the sky-line. The enemy, spreading round three sides of the mountain, crept up unseen and surprised them on the summit, who, exhausted by the night march, were sleeping in blissful ignorance of an impending attack. The disaster that ensued has been freely attributed to the decadence of our soldiers, resulting from modern changes of organization in the British Army; but to all who have visited the fatal hill, the fact is patent that defeat, under the circumstances, was inevitable. The troops, many of whom had already experienced the deadliness of the Boer rifle, were not only surprised, but almost surrounded; they were in complete ignorance of the numbers opposed to them, all felt that an organized retreat from such a position was an impossibility; while the unfortunate mingling of different regiments engendered a natural want of confidence. It required only the flight of a few of the more fainthearted to convert the British line into a disorded mass, rushing wildly down the rocks and boulders towards the camp in the valley below: while the Boers,

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quite taken aback by the completeness of their victory, after a few moments, mercifully forebore from firing on the flying crowd.

It must be remembered that in this war we had no Cavalry. Against Mounted Infantry, Cavalry would, without doubt, be very effective. Infantry in extended order attacked by Cavalry, form square, and have nothing to fear from the horsemen, although liable in such compact formation to suffer from the hostile Artillery; the mounted Boers, having no bayonets when fighting on foot, would have been at a great disadvantage. Had not the war come to an abrupt and unexpected conclusion, the two Cavalry Regiments that were hurrying up country to Sir G. Colley's assistance would, without doubt, have played an important part in the assault of Laing's Nek, should it have been decided upon to attack the entrenchments.

Demonstrations of Infantry against the right of the Boer position, the Cavalry moved up silently and gradually massed in the centre, Artillery fire on all points to keep concealed to the last the true point of attack, a determined assault by Infantry on the conical hill on the left, followed by a sudden charge of squadron after squadron up the glacis slope in the centre, wheeling successively to the right on reaching the summit, and riding through the Boer trenches till they joined hands with the Infantry;—by some such attack the whole left of the position would have been in our hands, and the road to Pretoria open. There would have been ample troops to bring such an operation to a brilliant termination within a month of the Majuba disaster. To inflict a decisive defeat on such an enemy, without Cavalry, was an impossibility.

The Egyptian War.

The recent Egyptian War, although short in duration, presents some useful tactical examples. As, however, no reliable history of the operations has yet been published, it is difficult to speak of what occurred in the various engagements with certainty.

Railways played an important part in Egypt. Strategically speaking railways are of greater value to the defensive than to the offensive; the former possess the power of depriving their opponents of the use of the lines while retaining it to themselves. Arabi, however, only partially destroyed the railways in retiring, and large quantities of rolling stock were captured in the rapid advance to Kassassin. The construction of an ironclad train, which proved itself of great use on several occasions in harassing the enemy, must be looked upon as a new departure in war.

The seizure of the important strategical point of Kassassin was due principally to the forward tactics of the Cavalry and Artillery. The Cavalry, during the remarkable advance along the fresh water canal, invariably succeeded in outflanking the enemy, while the Artillery and the small force of Infantry that succeeded in getting up to the front, occupied his attention in front. In the Egyptian attack on Graham's Brigade at Kassassin, they endeavoured, towards the close of the day, to turn his right flank; the situation being somewhat critical, the

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Cavalry Brigade, under Drury-Lowe, was brought up, and by making a long detour, came on the left flank of the Egyptians, who were working round towards Graham's rear. The night charge that ensued averted the danger. It has frequently been suggested that if at Gravelotte the French Reserves, instead of remaining inactive in rear of the centre, had moved down the Moselle Valley, and fallen on the outer flank of the German Corps, that were turning to the right at Doncourt and St. Privat, the battle might have had a very different result. Such a movement would have been analagous, only of course on a far greater scale, to the above Cavalry attack. At Rosbach, Frederick met the cumbrous French turning movement by taking up a new position and falling on the heads of the hostile columns. At Austerlitz, Napoleon, while opposing part of his Army to the Allied turning movement in front, flung the main body into the gap that occurred between the containing and the turning forces of the enemy. Wellington at Salamanca broke into the space that occurred between the Division that was moving round his right flank, and the remainder of Marmont's Army. These examples show three distinct methods of meeting a turning movement; it will be seen at a glance that Kassassin differs from each of these, and, while the mode of procedure employed by the defensive on this occasion is open to the objection of being a movement of separation, it cannot be denied that, in this particular case, the result was eminently satisfactory. The fact that Drury-Lowe was separated from Graham before the action, and that the two Brigades were practically working independently, does not in any way alter the case.

Tel-el-Kebir is chiefly remarkable, from a tactical point of view, on account of the night march that preceded the battle. Under cover of darkness it was possible to advance the Infantry in close formation within rifle range. The guns advanced, massed in the centre, but no sooner had the battle commenced than the Batteries separated, and worked more or less independently; the Artillery fire became divergent in place of being convergent. The circumstances of the case gave little scope for the action of Artillery in mass. It at first appears somewhat strange that the Cavalry, which, after the victory, moved to the left on Cairo, should have been placed on the right, while the Indian Contingent, after overthrowing the Egyptian left, marched straight on for Zagazig, the paths of the two forces thus crossing. When, however, we remember that the ground on the right was eminently suited to the movement of Cavalry, while that on the left was south of the canal, and that the Indian Contingent had always advanced on that side, we see at once the dispositions for attack was then best fitted for terminating the war at one blow.

General Considerations.

A brief consideration of the tactics employed by our Infantry in these wars, places it beyond doubt that many of the maxims laid down for the guidance of this Arm in European warfare, are either altogether inapplicable to combats against irregular warriors, or else require con-

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siderable modification to meet altered circumstances. The loose formation employed nowadays, alike in attack and defence, is recognised as the only means of counteracting the crushing fire of the breech-loader; the system of supports and reserves, adopted by Armies of the present day, is necessitated by the certain losses of the firing line, even in extended formation. When, however, Infantry is not exposed to such deadly fire, the *raison d'être* for scattered formation ceases to exist. On the defensive therefore, when the fire of the antagonist is no more formidable than was that of the Afghans and Zulus, two-deep line is perhaps the best formation for Infantry to meet an attack. On the offensive, however, an advance in line would voluntarily sacrifice the full power conferred on the foot soldier by his breech-loader, as it is obvious that men marching shoulder to shoulder cannot use fire-arms to advantage. One man to two paces is considered the closest formation in which Infantry can advance firing. The ill-directed fire of the Afghans permitted a line of skirmishers to advance close up with trifling loss; there was then no need of supports to fill up gaps in the firing line caused by men placed *hors de combat*. The sight of the bayonet at close quarters was generally sufficient to carry the firing line into the hostile positions without the intervention of reserves.

Against the Zulus our tactics were essentially defensive; and to meet the violent onslaught of these brave savages, the proper Infantry formation was unquestionably the two-deep line, giving the maximum possible fire effect, and at the same time presenting a solid line of bayonets to the advancing foe. The efficacy of the bayonet, which has been questioned by continental writers of late years, was abundantly proved at Tel-el-Kebir; but hand-to-hand fights have become exceptional, and there have been few instances in the wars under consideration of Infantry charging home. At Isandlwhana British bayonets kept the savage hordes at bay long after retreat had become impossible: at Maiwand also the cold steel did its work, but in most cases victory was decided by fire alone.

Whatever may be said as to the days of effective action by Cavalry on the field of battle being numbered in European warfare, our experiences of the last five years go to show that in our small wars at all events effective Cavalry charges are by no means a thing of the past. There is a very general opinion that in future wars between Armies provided with modern arms of precision, this Arm will exercise but a trifling and momentary effect on the course of actions: and there is much to be said in favor of this theory. The *rôle* assigned to the Cavalry by recent writers on tactics, is to see and hear but not to strike. Except under the most favorable conditions, such as during sudden confusion, or when a regular surprise can be effected, a charge of Cavalry must fail against disciplined Infantry, but the case is very different when Cavalry are enabled to attack an undisciplined mob. The charges in the Chardeh Valley, near Kabul, although unsuccessful in their object of saving the guns, caused great havoc amid the hostile ranks. Some days later a few Squadrons cleared the Siah Sung Plateau of swarms of the enemy. The night charge at Kassassin is still fresh in our memories.

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Cavalry, it is universally admitted, is of the greatest possible value after a victory in harassing the hostile retreat; in our small wars, however, the Cavalry do more than harass, they destroy. The Cavalry pursuits after Ulundi and Kandahar dissipated all vestige of opposition; the decisive nature of the victory at Tel-el-Kebir was greatly due to Drury-Lowe and his Troopers. That on many occasions Cavalry apparently failed to inflict serious loss in their pursuits in Afghanistan, was chiefly caused by the manner in which the enemy, after once dispersing disappeared into villages, where they threw down their arms, and re-appeared assuming a peaceful and friendly aspect. Cavalry often suffers severe loss from advancing too far, carried away by the impetuosity of the charge; but there are no instances of this in these wars; and, while granting that the best explanation for this fact is the inability of undisciplined armies to deliver a counter attack, some credit is also due to the Cavalry. Continental critics are mistrusting in their praises of our horsemen during the Egyptian War.

Modern experience has assigned to Cavalry the duty of spreading out in front of an Army a curtain, behind which its dispositions are concealed. This "strategic veil" pushes out several marches ahead of the main body, feeling for the enemy, watching his movements and keeping the General in rear acquainted with what is going forward. It is obvious that Cavalry can only be employed in this fashion with large Armies. At the opening of the Franco-German War the Cavalry screen in advance of the First and Second German Armies extended nearly 50 miles, and was thrown out 20 miles beyond the heads of the invading columns. The proportion of Cavalry allowed to this host of 300,000 men was amply sufficient for the work, but the single Regiment attached to a Division would be quite unequal to the task of covering the advance of this small force if moving in several columns, even if only half the distance in front.

Except in the case of the Boer War our Armies in the field have of late years always been accompanied by a fair proportion of Cavalry and Mounted Infantry; and the frequent surprises to which our troops have been subjected, would seem to point to a lack of training in outpost duties. "No Army that is able to manœuvre, and the Cavalry of which is properly posted and does its duty, should ever, under any circumstances whatever, be surprised by a flank attack;" yet at Ahmed Kehl, the appearance of the enemy on the left flank was quite unexpected.

In Afghanistan the thoroughly guerilla nature of the war rendered it unsafe to push horsemen far to the front, whether singly or in small groups; for these would have been liable at any moment to be cut off by ostensibly peaceable villagers. This danger did not exist in Egypt, nor to the same extent in Zululand; and in the latter country, after the experiences gained in the early struggles, Mounted Rifles and Cavalry were usually well to the front, and the reconnoitring duties were well performed.

The demoralization that is sure to ensue among Cavalry when exposed for a length of time to an effective fire, was strikingly exemplified by the failure of the Native Horse at Maiwand. That

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Cavalry cannot act on the defensive was shown at Ahmed Kehl, when the Squadrons on the left, being unexpectedly charged by Afghan horsemen, who had advanced unseen up some ravines, were thrown into the utmost confusion and beat a hasty retreat.

The occasions on which Cavalry acted dismounted were infrequent, and the results as a rule not very satisfactory. The ordinary mode of procedure, by which a Squadron places only half a Troop in firing line, while the remainder act as horse holders and as supports, points unmistakably to the fact that Cavalry can only be employed in this manner under abnormal circumstances; still the necessity for the supports only exists where the enemy possesses mounted troops. In Zululand the Irregular Horse did good service, trusting almost entirely to their rifles, as there was no fear of a Cavalry attack.

Our Artillery tactics in these wars are chiefly remarkable for the boldness with which the guns have always been pushed to the front. Todleben, in his "History of the Crimean War," praises the manner in which our guns always supported the Infantry; but since that date Artillery has assumed a far more important *rôle* on the field of battle than was formerly the case.

There have been many instances of forward Artillery tactics, both in Afghanistan and Egypt, but it must be remembered that the inferiority of the enemy justified an advance of guns to such close range as could seldom be risked in European warfare. At Maiwand, Maclaine dashed more than a mile to the front with his Division, escorted by only a Troop of Cavalry, and opened fire at short range, but no attempt was made to "rush" his guns. Some of the guns at Ahmed Kehl, in advance of the line when the "Ghazis" made their furious onslaught, stood their ground a considerable time, firing case and reversed shrapnel, with trifling loss. It is a significant fact that, with the single exception of Parson's guns at the Ingogo, there is no instance of our Artillery having been *silenced* in any of the engagements of these wars.[1] In the Chardeh Valley the Horse Artillery guns were spiked and abandoned, as it appeared impossible to withdraw them; but there was practically no loss in horses or men. On the Asmai heights two mountain guns were lost, owing to the sudden retreat of the Infantry before an overwhelming mass of Afghans. At Maiwand and Isandlwhana our guns were captured, but in none of these cases was the Artillery silenced. At Tel-el-Mahuta two Horse Artillery guns fought the entire day against three or four Egyptian Batteries, and although suffering severely, remained in action as long as was required.

It is obvious, therefore, that when opposed to an uncivilized enemy, Artillery can fight in situations where it would be destroyed in European warfare. At the Battle of Kandahar, the screw gun battery pushed along with MacPherson's Brigade, after the hostile right had been turned, and came into action actually in advance of the Infantry.

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[1] [Parson's guns, it must be remembered, were silenced from his men having been shot down—as he was himself.—*H.W.L.H.*]

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The value of Mountain Artillery has been long recognized in India. That the use of them is by no means confined to hilly country, is proved by the good performance of the screw gun battery in Egypt. It is easy to conceive situations where, in level country, it might be impossible to bring field guns, while guns carried on pack animals could be manœuvred with ease. In the march from Kabul to Kandahar General Roberts preferred to take only Mountain Artillery, although the same ground had been traversed some months before by the ponderous elephant battery.

The expedient of carrying guns by manual labor has been frequently resorted to in default of mules; this was the case in Ashanti. In the expedition to the Naga hills two guns carried by coolies did excellent service. These latter, in the attack on Konoma, were brought up into the first of the two forts held by the enemy, as soon as it was captured, and opened fire on the second at 50 yards range. Mountain Batteries have as yet been little used in Continental wars, but our experiences on the frontiers of India fully justify the introduction of this service at home. Had mountain guns been taken to Majuba Hill the Boers would never have ventured to storm the heights: indeed, the moral effect of Artillery fire opening on the hostile laager, which was within easy range, would probably have led to the evacuation of the Laing's Nek position. Field guns can be used like Mountain Artillery by placing them on elephants. This was frequently done in Afghanistan; the flank attack on the Peiwar Kotal was accompanied by four Royal Horse Artillery guns on elephants, although they arrived too late to exert much influence on the fight, while the Native Mountain Battery advanced with the Infantry throughout the day. There are no doubt cases where this mode of procedure is permissible, and under certain circumstances it may be unavoidable, but it is manifestly an exceptional and dangerous expedient. The guns cannot manœuvre confidently, and the timid dispositions of elephants render them very liable to panic in action.

The moral effect of even indifferently directed Artillery fire is shown by the poor stand made by the Native troops at Maiwand, after two hours' pounding from Ayoub Khan's guns; that it should terrify savages is only to be expected, and in our small wars our branch of the service always plays an important part. The Boers greatly dreaded the effect of our guns.

The massing of the Artillery at Tel-el-Kebir has already been referred to. At the Battle of Kandahar, General Roberts might have massed nearly 30 guns against the villages on the right of the Afghan position, but preferred to keep his Batteries dispersed so as to distract the enemy's attention. These are the only two instances of attacks on a large scale by our troops. On the defensive, modern writers admit that the massing of guns is of doubtful value, dispersion is necessary so as to cover all possible approaches. In the defensive actions in Zululand, the field and Gatling guns were always scattered about among the Infantry, and although at Maiwand and Ahmed Kehl the Artillery kept together, this fact was due more to accident than design, and the fire would probably have been more effective had the contrary been the case.

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As regards the proportion of guns to the number of troops, we find that this has varied greatly during these wars. In his march from Kabul to Kandahar, Roberts only took 18 guns, giving only 1·6 per 1000 men; it must, however, be remembered that Artillery could be counted upon from the beseiged garrison of Kandahar. In the battle there were 30 guns to nearly 15,000 men, a small proportion of only 2 guns per 1000. At Ahmed Kehl the proportion was under 3 per 1000. It was at one time estimated that in the whole of Afghanistan the proportion was 3·5 per 1000, but many of the guns were frittered away on the lines of communication. In Zululand the proportion was always below 3 per 1000; at Ulundi there were only 12 guns to over 5000 men; at Ginghilovo the proportion was considerably lower. In the Boer war, also, Artillery was scarce: General Colley was most anxious to have more guns. At Tel-el-Kebir the proportion of guns to the number of men actually engaged was very high; there were altogether more than 60 guns to a force of 12,000 men, or 5 guns per 1000.

Those who have deeply studied the latest developments of modern tactics, have arrived at the conclusion that one of the consequences of the rapid strides taken in the improvement of fire-arms, will be a great increase in the frequency of night attacks. The confusion inseparable from the movement of large bodies of men in the dark will be risked rather than frontal assaults by day on troops armed with the breech-loader. It is singular that the Afghans and Zulus seldom ventured on night attacks, although they must have instinctively recognized that darkness placed them almost on an equality with our men as regards weapons. The attack on Rorke's Drift was continued far into the night, but the lurid glare thrown by the burning hospital enabled the defenders to use their rifles. Fort Battye, one of the posts in the Jellalabad Valley, was attacked one night by Shinwarris, who were only beaten off after a severe struggle, in which the small garrison lost considerably. The disaster in the Tutanli river arose from the Zulus creeping up in the darkness and surprising our men at dawn. In the New Zealand War the Maories nearly succeeded in surprising one of our stockades at night; but a long experience of war against savage tribes shows that such tactics are unusual.

While we find no case of our troops delivering an attack by night, we see several instances of night marches in presence of the enemy. Making a wide detour, under cover of darkness, the major portion of Roberts' force arrived on the flank of the Afghan position at the Peiwar Kotal before daybreak, the result being a complete surprise of the enemy at that point. The night expedition to Majuba Hill is remarkable, chiefly for the complete success with which a considerable body of Infantry were brought over most difficult and rugged ground in the dark, undiscovered by an alert and wary foe distant only a few hundred yards: the retreat from the Ingogo battle field to the camp at Mount Prospect, through a country infested with Boers, is another singular instance of night marching. The march to Tel-el-Kebir has scarcely a parallel in the history of war. That 12,000 men should advance in line of battle for several miles by night, guided alone by the

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stars, without confusion or delay, would appear extraordinary, were it not for the fact that practically no impediments existed in the line of march. That this force should push up to the very ditch of a formidable line of entrenchments, held by troops provided with Artillery and armed with breech-loading rifles, without raising an alarm in the hostile lines, can only be explained by an unaccountable want of vigilance on the part of the enemy. In broken or cultivated country such a movement would be entirely out of the question; moreover in northern latitudes stars could hardly be depended upon for guidance. Abercrombie at one time contemplated a night attack on the French entrenchments near Aboukir, very similar to Wolseley's on Tel-el-Kebir; historians of the war consider this to have been a desperate project; the enterprise was abandoned owing to the retirement of the French. The very best armies are at night liable to panic; if this is the case with disciplined soldiers it is scarcely to be wondered at that warriors, such as we generally find opposed to us in small wars, should hesitate before committing themselves to an attack in the darkness on civilized troops, aided by the scientific appliances that their superstition ascribes to witchcraft.

Long range fire was first brought into prominence during the Russo-Turkish War; but, although against masses of Zulus, such fire might have been employed with good effect, it does not ever appear to have been tried, nor do our soldiers seem to have fired, as a rule, at ranges exceeding 600 yards. At the Peiwar Kotal the Infantry in front of the position succeeded in silencing several hostile guns at ranges over 800 yards; and this example is interesting, as showing the danger of exposing Artillery to Infantry fire. Boers picked off individuals at considerably longer ranges, but such marksmanship is a new experience in war.

The question of Mounted Infantry, which of late years has exacted considerable attraction, is at present in abeyance. This "new and bastard Arm," as it was lately stigmatized in a masterly treatise on Modern Tactics, has never, except in the War of Secession, been used on a great scale: indeed, the wars in South Africa afford almost the best examples of the use of Mounted Riflemen. Whatever arguments may be brought to bear against the introduction of Mounted Infantry, there is strong evidence to show that Cavalry is at present quite unfit for manœuvring on foot. If it be true, as is laid down by Captain Jocelyn in his valuable "Short Notes," that "Cavalry skirmishing on foot can never advance to attack an enemy's Infantry," then the sooner a body of Infantry be permanently trained for acting mounted when possible, the better. This force must abandon all idea of fighting on horseback.

The true tactical application of machine guns is a subject of controversy, their conspicuous failure in the Franco-Prussian War rendered them unpopular before the break down of the Gatling in Afghanistan and South Africa. Of the true use of the machine gun, we have learnt nothing in our small wars; at Ginghilovo, under exceptionably favorable conditions, the Gatling did enormous execution, but its faulty construction frequently prevented this weapon from firing

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a single round. In spite, however, of the unsatisfactory results as yet obtained from mitrailleuses, these new engines of war are, without doubt, destined to exert an important influence over the Military history of the future.

The one great lesson however to be learnt from our recent campaigns is not one of tactics. To commence war unprepared, no matter how contemptible the foe, is but to court defeat and disaster. "All history" says Jomini "teaches that no enemy is so insignificant as to be despised and neglected by any power, however formidable." The Afghan War, entered upon with an inadequate force, and carried on at first with insufficient vigour, lasted two years, cost twenty millions, and has left no enduring result: the reverses in South Africa arose from holding our antagonists too cheap. The nature of the Egyptian rising was more correctly gauged, and within three weeks of the arrival of the well-equipped British force, the delta of the Nile was at our mercy.

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GARRISON GUN DRILL.

BY

CAPT. F. G. I. LILLINGSTON,
2ND BRIGADE, CINQUE PORTS DIVISION, R.A.

COMMUNICATED BY

COLONEL W. H. GOODENOUGH, C.B., R.A.

I AM desirous of submitting for consideration the following suggestions concerning certain points in the drill of Garrison Artillery:—

I served for many years in the Royal Navy, and in my humble opinion there are a few details which I think the Royal Artillery might copy with advantage from the sister service.

What I consider the most important point is that Nos. 1 should fire their own guns ALWAYS, not only at moving objects but in every drill, and that therefore all garrison guns should be fitted with guide-plates for the tube lanyards, as Naval guns are. I feel confident that unless Nos. 1 fire their own guns at ships steaming across range—say, at from 9 to 16 knots—they will never make anything like good shooting, and that they should be trained in peace time to do this *always*, firing when their two sights and the object aimed at come in line. If not kept at this practice in peace time they will be all adrift in time of war. To do this, they must remain on the traversing platforms (and not be taught to climb up and down, and to give the order to another number (No. 5) to fire), using their own discretion, and when the sights come on pull the tube lanyard themselves. The objection may be raised that there is not room in rear of the guns for the Nos. 1 to stand. My answer is, that room may be made for them by hooking on a wooden platform in rear for them to stand on. I cannot help thinking that the reason our ships were not struck oftener at the Bombardment of Alexandria was that the present system of firing must have been carried out by the Egyptian gunners, whilst the havoc caused by the guns afloat was due to the Nos. 1 on board *our* ships firing their own guns.

These are not my own inventions or ideas, but, having had the experience of both naval and military drills, I have had the opportunity of observing where there are weak points, and so much am I imbued

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with the feeling that this change would be of advantage to the country that I hope I will be forgiven for suggesting it.

Some Artillery Officers, to whom I have spoken on the subject, seem to think that the reason why the Nos. 1 on board men-of-war fire their own guns is because the ships are generally rolling more or less, and they have to fire as their sights and object aimed at come in one. This is certainly true; but if they have to fire their own guns to enable them to do this when the motion is perpendicular, it holds good that it is equally necessary to do the same if the motion is horizontal instead, which it is when a ship is steaming across range.

I have been informed that the Germans use a shield to protect the Nos. 1 in rear of their platforms, which, I take it, means that *they* fire their own guns.

Another suggestion I would like to offer is that every garrison with a harbour should be supplied with a swift steam launch to tow targets across range for practice, or else be empowered to borrow a steamer for the practice days from the Navy if possible, or hire from some private firm if a Government boat could not be got.

I will conclude by saying that I fear our garrison at Dover would stand a poor chance were a hostile navy to send a fleet and bombard that town under the present system of firing our guns.

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WILD-FOWL AND PUNT GUNS.

BY

MAJOR W. McCLINTOCK, R.A.,

Assistant Superintendent, Royal Small Arms Factory, Enfield.

In "Proceedings, Royal Artillery Institution," No. 6, Vol. XII., a paper was published which gave the results of a series of experiments made to test the muzzle velocity of small shot when fired from 12-bore guns, and an attempt was also made to show how much the muzzle velocity of the shot depended on the cartridges being correctly loaded, and especially on the quality of the powder used in loading them.

Tables were added which gave the remaining velocity, time of flight, and energy of Nos. 8, 6, and 5 shot at every ten yards of range, when fired with such muzzle velocities as ordinary cartridges are likely to give.

Wild-fowl guns form the subject of the present paper, which is intended to supply information as to what muzzle velocity should be obtained with the different types of these guns when firing the usual charges.

Two or more different charges were used with each gun when taking the velocities, and the reader can, by observing the muzzle velocities due to them, so adjust his charges that, without having access to a velocity instrument, he will be able, very approximately, to regulate the velocity of the shot he fires.

It will be sufficient for him to remember that the velocity depends principally on the following conditions:—

1. Quality of the powder.
2. The proportion of weight of powder-charge to weight of shot-charge.
3. The length of the bore of the gun.

Tables have been calculated for No. 4, BB, BBBB, and SSG shot, which give similar information to that already supplied for the smaller sizes, and a study of these tables will enable the reader to decide which is the most advantageous size of shot for him to make use of.

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These tables have been calculated for "Newcastle chilled shot," so will not be absolutely correct for shot by other makers, but they are sufficiently accurate for all practical purposes.

The following gives the result of carefully measuring the diameters of twenty pellets of each size :—

Pellets.	No. 4 Shot.	B B Shot.	B B B B Shot.	S S G Shot.
	inch.	inch.	inch.	inch.
1	0·118	0·158	0·177	0·276
2	0·120	0·154	0·1765	0·277
3	0·114	0·159	0·173	0·281
4	0·1165	0·158	0·171	0·279
5	0·119	0·1595	0·1765	0·280
6	0·1275	0·156	0·175	0·278
7	0·121	0·1585	0·172	0·278
8	0·120	0·161	0·1755	0·277
9	0·119	0·1585	0·177	0·276
10	0·114	0·157	0·179	0·275
11	0·118	0·1565	0·172	0·276
12	0·116	0·157	0·175	0·278
13	0·115	0·1575	0·1715	0·279
14	0·1105	0·160	0·178	0·276
15	0·121	0·157	0·173	0·281
16	0·114	0·159	0·177	0·277
17	0·118	0·155	0·174	0·280
18	0·120	0·161	0·179	0·281
19	0·1175	0·1595	0·172	0·278
20	0·121	0·158	0·173	0·279
	20)2·3600	20)3·160	20)3·497	20)5·562
Mean diameters ...	0·118	0·158	0·17485	0·2781

The weights were found to be as follows :—

	No. 4 Shot.	B B Shot.	B B B B Shot.	S S G Shot.
	grains.	grains.	grains.	grains.
Weight of 100 pellets	244	552	784	3254
Weight of 1 pellet ...	2·44	5·52	7·84	32·54
Value of $\frac{d^2}{w}$	39·95	31·66	27·17	16·63

The value of $\frac{d^2}{w}$ being calculated from the mean diameters and mean weights.

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TABLE I.—Giving particulars of the Guns and Charges fired from them, and the Muzzle Velocities obtained.

Nature of Gun.	Length of Barrel.	Weight.	Charge.		Proportion of weight of powder to weight of shot.	Muzzle Velocity.	Recoil.
			Powder.	Shot.			
	Inches.	lbs. ozs.	Drams.	ozs.		f. s.	ft.-lbs.
10-bore Double-barrel Wild-fowl Gun (choke-bore)	31⅛	9 0	4½ C. & H. No. 6 T. S.	1½	1 : 5·33	1344	32·71
Ditto	"	"	4 C. & H. No. 6 T. S.	1¼	1 : 7	1184	33·18
8-bore Double-barrel Wild-fowl Gun (choke-bore)	34	12 10	6 C. & H. No. 6 T. S.	2	1 : 5·33	1393	44·53
Ditto	"	"	7½ C. & H. No. 6 T. S.	2½	1 : 5·33	1411	71·34
Ditto	"	"	8 C. & H. No. 6 T. S.	2½	1 : 5	1452	76·40
4-bore Single-barrel Wild-fowl Gun (choke-bore)	36	14 6	8½ C. & H. No. 7 T. S.	3	1 : 5·64	1282	73·92
Ditto	"	"	9 C. & H. No. 7 T. S.	3½	1 : 6·22	1265	96·47
Ditto	"	"	10 C. & H. No. 7 T. S.	3	1 : 4·8	1424	93·63
4-bore Double-barrel Wild-fowl Gun (choke-bore)	38	16 12	8½ C. & H. No. 7 T. S.	3	1 : 5·64	1341	69·26
Ditto	"	"	9 C. & H. No. 7 T. S.	3½	1 : 6·22	1279	84·47
Ditto	"	"	10 C. & H. No. 7 T. S.	3	1 : 4·8	1430	81·02
	ft. in.	cwt. qrs. lbs.	ozs.	lbs.		f. s.	ft.-lbs.
1½-inch Punt Gun, C. F., cylindrical steel barrel, "The London" breech action	8 6	1 1 4½	3 C. & H., Col. Hawker's grain	1	1 : 5·33	1542	305·5
Ditto	"	"	4 C. & H., Col. Hawker's grain	1¼	1 : 5	1721	600·6
1½-inch Punt Gun, C. F., choke-bore, steel barrel, "The London" breech action	8 7	1 1 15	3 C. & H., Col. Hawker's grain	1	1 : 5·33	1573	296·4
Ditto	"	"	4 C. & H., Col. Hawker's grain	1¼	1 : 5	1725	562·6
2-inch Punt Gun, C. F., cylindrical steel barrel, "The London" breech action	9 6½	1 2 0	6 C. & H., Col. Hawker's grain	2	1 : 5·33	1717	1301

NOTE.—The Punt Guns were obtained from Messrs. Holland & Holland, and the Wild-fowl Guns from Messrs. J. & W. Tolley, these firms having very kindly lent the guns and supplied the cartridges for the experiment.

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No. 4 SHOT.

TABLE II.—Showing Remaining Velocity, Energy, and Time of Flight of each Pellet at various Ranges.

Range.	Muzzle velocity=1500 f.s.			Muzzle velocity=1400 f.s.			Muzzle velocity=1300 f.s.			Muzzle velocity=1200 f.s.			Muzzle velocity=1100 f.s.			Muzzle velocity=1000 f.s.		
	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.
Yards.	f.s.	ft.-lbs.	Seconds.	f.s.	ft.-lbs.	Seconds.	f.s.	ft.-lbs.	Seconds.	f.s.	ft.-lbs.	Seconds.	f.s.	ft.-lbs.	Seconds.	f.s.	ft.-lbs.	Seconds.
10	1190	7·663	0·02250	1119	6·774	0·02405	1052	5·989	0·02577	989	5·294	0·02765	926	4·640	0·02981	857	3·976	0·03260
20	982	5·219	0·05051	938	4·762	0·05348	894	4·325	0·05680	849	3·901	0·06059	803	3·489	0·06460	751	3·052	0·06985
30	844	3·855	0·08364	812	3·570	0·08786	778	3·276	0·09309	744	2·996	0·09054	708	2·713	0·1048	668	2·415	0·1122
40	741	2·972	0·1214	715	2·767	0·1276	689	2·569	0·1342	663	2·379	0·1409	634	2·176	0·1494	601	1·955	0·1599
50	660	2·357	0·1644	640	2·217	0·1716	619	2·074	0·1797	597	1·930	0·1889	574	1·783	0·1989	547	1·619	0·2118
60	595	1·916	0·2122	578	1·808	0·2215	561	1·704	0·2311	543	1·596	0·2419	524	1·486	0·2537	501	1·358	0·2699
70	541	1·584	0·2658	528	1·509	0·2753	513	1·424	0·2873	498	1·342	0·2998	...	...	...	...	...	...
80	497	1·338	0·3228	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

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TABLE III.—Showing Remaining Velocity, Energy, and Time of Flight of each Pellet, at various Ranges.

Range.	Muzzle velocity = 1800 f.s.			Muzzle velocity = 1700 f.s.			Muzzle velocity = 1600 f.s.		
	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.
Yards.	f.s.	ft.-lbs.	Seconds.	f.s.	ft.-lbs.	Seconds.	f.s.	ft.-lbs.	Seconds.
10	1483	26·94	0·01839	1403	24·09	0·01945	1324	21·48	0·02063
20	1232	18·58	0·04069	1171	16·79	0·04292	1112	15·14	0·04541
30	1047	13·42	0·06708	1005	12·36	0·07063	964	11·38	0·07464
40	918	10·31	0·09795	887	9·632	0·1025	856	8·973	0·1076
50	819	8·213	0·1326	794	7·718	0·1386	769	7·240	0·1448
60	740	6·704	0·1710	719	6·328	0·1783	699	5·982	0·1855
70	674	5·563	0·2138	657	5·285	0·2219	640	5·016	0·2305
80	619	4·691	0·2604	604	4·466	0·2705	590	4·263	0·2797
90	573	4·021	0·3102	560	3·840	0·3215	548	3·677	0·3320
100	533	3·477	0·3645	522	3·336	0·3765	511	3·197	0·3891
110	498	3·036	0·4230	...	...	...	...	...	...

Range.	Muzzle velocity = 1500 f.s.			Muzzle velocity = 1400 f.s.			Muzzle velocity = 1300 f.s.		
	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.
Yards.	f.s.	ft.-lbs.	Seconds.	f.s.	ft.-lbs.	Seconds.	f.s.	ft.-lbs.	Seconds.
10	1246	19·01	0·02199	1169	16·74	0·02347	1094	14·66	0·02533
20	1056	13·66	0·04822	1003	12·31	0·05136	952	11·09	0·05483
30	925	10·47	0·07872	886	9·610	0·08318	846	8·764	0·08839
40	825	8·335	0·1131	794	7·718	0·1188	762	7·111	0·1255
50	744	6·778	0·1516	719	6·328	0·1586	692	5·862	0·1673
60	678	5·627	0·1936	657	5·285	0·2022	635	4·938	0·2120
70	623	4·752	0·2395	604	4·466	0·2507	586	4·205	0·2614
80	575	4·019	0·2906	560	3·840	0·3019	544	3·623	0·3147
90	535	3·505	0·3443	522	3·336	0·3570	508	3·160	0·3715
100	500	3·061	0·4021	...	...	...	...	...	...
110	...	...	...	...	...	...	...	...	...

Range.	Muzzle velocity = 1200 f.s.			Muzzle velocity = 1100. f.s.			Muzzle velocity = 1000 f.s.		
	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.
Yards.	f.s.	ft.-lbs.	Seconds.	f.s.	ft.-lbs.	Seconds.	f.s.	ft.-lbs.	Seconds.
10	1024	12·83	0·02723	956	11·19	0·02941	883	9·548	0·03215
20	902	9·961	0·05839	850	8·845	0·06252	792	7·679	0·06772
30	806	7·945	0·09385	761	7·147	0·1001	717	6·294	0·1078
40	729	6·506	0·1329	695	5·914	0·1409	655	5·252	0·1518
50	665	5·414	0·1763	636	4·953	0·1867	603	4·451	0·1997
60	612	4·586	0·2229	587	4·218	0·2358	559	3·825	0·2511
70	567	3·937	0·2733	545	3·637	0·2889	521	3·323	0·3064
80	527	3·400	0·3291	509	3·172	0·3452	...	...	...
90	493	2·975	0·3879	...	...	...	...	...	...
100	...	...	...	...	...	...	...	...	...
110	...	...	...	...	...	...	...	...	...

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TABLE IV.—Showing Remaining Velocity, Energy, and Time of Flight of each Pellet, at various Ranges.

Range.	Muzzle velocity = 1800 f.s.			Muzzle velocity = 1700 f.s.			Muzzle velocity = 1600 f.s.		
	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.
Yards.	f.s.	ft.-lbs.	Seconds.	f.s.	ft.-lbs.	Seconds.	f.s.	ft.-lbs.	Seconds.
10	1524	40·37	0·01811	1441	36·12	0·01917	1359	32·11	0·02035
20	1297	29·26	0·03954	1230	26·31	0·04181	1165	23·61	0·04427
30	1117	21·65	0·06451	1067	19·80	0·06810	1020	18·09	0·07194
40	986	16·90	0·09317	950	15·70	0·09781	914	14·52	0·1030
50	887	13·68	0·1254	858	12·80	0·1311	829	11·95	0·1374
60	807	11·32	0·1605	782	10·64	0·1680	758	9·993	0·1754
70	739	9·495	0·1999	719	8·989	0·2078	698	8·474	0·2168
80	682	8·089	0·2423	665	7·690	0·2513	647	7·280	0·2616
90	634	6·990	0·2873	619	6·664	0·2977	603	6·323	0·3096
100	591	6·074	0·3371	578	5·809	0·3485	565	5·550	0·3606
110	554	5·387	0·3897	543	5·128	0·4016	531	4·904	0·4155
120	522	4·740	0·4445	512	4·559	0·4578	501	4·364	0·4742

Range.	Muzzle velocity = 1500 f.s.			Muzzle velocity = 1400 f.s.			Muzzle velocity = 1300 f.s.		
	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.
Yards.	f.s.	ft.-lbs.	Seconds.	f.s.	ft.-lbs.	Seconds.	f.s.	ft.-lbs.	Seconds.
10	1278	28·41	0·02171	1198	24·97	0·02315	1119	21·76	0·02502
20	1103	21·14	0·01699	1044	18·95	0·05000	988	16·97	0·05347
30	976	16·56	0·07595	932	15·10	0·08058	888	13·71	0·08578
40	879	13·44	0·1084	843	12·36	0·1147	808	11·35	0·1209
50	800	11·13	0·1441	770	10·31	0·1518	740	9·521	0·1600
60	734	9·369	0·1831	709	8·734	0·1921	683	8·112	0·2023
70	678	7·993	0·2256	656	7·484	0·2365	634	6·990	0·2480
80	629	6·882	0·2724	611	6·491	0·2838	592	6·094	0·2966
90	588	6·013	0·3209	572	5·690	0·3339	555	5·357	0·3489
100	551	5·281	0·3744	537	5·016	0·3890	522	4·740	0·4055
110	519	4·685	0·4302	506	4·453	0·4470	...	...	...
120	...	...	...	...	...	...	...	...	...

Range.	Muzzle velocity = 1200 f.s.			Muzzle velocity = 1100 f.s.			Muzzle velocity = 1000 f.s.		
	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.
Yards.	f.s.	ft.-lbs.	Seconds.	f.s.	ft.-lbs.	Seconds.	f.s.	ft.-lbs.	Seconds.
10	1045	18·99	0·02689	974	16·50	0·02896	898	14·03	0·03179
20	933	15·14	0·05736	877	13·38	0·06163	816	11·58	0·06661
30	844	12·39	0·09131	798	11·08	0·09757	747	9·703	0·1052
40	771	10·34	0·1283	732	9·317	0·1370	689	8·254	0·1471
50	709	8·740	0·1692	677	7·971	0·1789	639	7·101	0·1926
60	657	7·509	0·2127	629	6·882	0·2249	596	6·176	0·2413
70	612	6·515	0·2597	587	5·991	0·2748	559	5·434	0·2925
80	572	5·690	0·3112	551	5·281	0·3268	526	4·811	0·3477
90	537	5·016	0·3659	518	4·666	0·3845	496	4·279	0·4076
100	507	4·470	0·4220	...	...	...	...	...	...
110	...	...	...	...	...	...	...	...	...
120	...	...	...	...	...	...	...	...	...

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SSG SHOT.

TABLE V.—Showing Remaining Velocity, Energy, and Time of Flight of each Pellet, at various Ranges.

Range.	Muzzle velocity = 1800 f.s.			Muzzle velocity = 1700 f.s.			Muzzle velocity = 1600 f.s.		
	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.
Yards.	f.s.	ft.-lbs.	Seconds.	f.s.	ft.-lbs.	Seconds.	f.s.	ft.-lbs.	Seconds.
10	1625	190·5	0·01750	1535	170·0	0·01864	1447	151·1	0·01966
20	1469	155·8	0·03693	1390	139·4	0·03903	1312	124·3	0·04143
30	1331	127·8	0·05845	1262	115·0	0·06175	1194	102·9	0·06543
40	1210	105·7	0·08221	1151	95·63	0·08672	1094	86·42	0·09181
50	1108	88·55	0·1080	1059	80·95	0·1140	1013	74·03	0·1203
60	1024	75·68	0·1363	985	70·01	0·1432	946	64·60	0·1510
70	956	65·98	0·1663	922	61·35	0·1747	888	56·92	0·1838
80	896	57·94	0·1993	867	54·25	0·2081	837	50·56	0·2184
90	844	51·40	0·2336	818	48·31	0·2439	791	45·16	0·2556
100	798	45·96	0·2699	774	43·23	0·2818	750	40·61	0·2915
110	756	41·25	0·3088	736	39·10	0·3203	713	36·69	0·3357
120	719	37·31	0·3489	700	35·37	0·3625	680	33·37	0·3783
130	685	33·87	0·3917	668	32·21	0·4062	649	30·40	0·4242
140	654	30·87	0·4367	638	29·38	0·4530	622	27·93	0·4700
150	626	28·29	0·4832	611	26·95	0·5012	596	25·64	0·5201
160	600	25·99	0·5322	587	24·86	0·5498	572	23·61	0·5724
170	576	23·94	0·5837	564	22·96	0·6024	551	21·92	0·6240
180	554	22·15	0·6368	543	21·28	0·6560	531	20·35	0·6787
190	533	20·50	0·6939	523	19·74	0·7139	512	18·92	0·7372
200	514	19·07	0·7516	505	18·41	0·7714	...	...	...
210	497	17·83	0·8081	...	...	...	...	...	...

Range.	Muzzle velocity = 1500 f.s.			Muzzle velocity = 1400 f.s.			Muzzle velocity = 1300 f.s.		
	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.
Yards.	f.s.	ft.-lbs.	Seconds.	f.s.	ft.-lbs.	Seconds.	f.s.	ft.-lbs.	Seconds.
10	1359	133·2	0·02092	1271	116·6	0·02243	1184	101·2	0·02417
20	1235	110·1	0·04414	1159	96·06	0·04714	1086	85·15	0·05069
30	1128	91·79	0·06969	1065	81·89	0·0737	1007	73·14	0·07920
40	1040	78·05	0·09752	990	70·73	0·1034	940	63·77	0·1105
50	969	67·63	0·1274	926	61·89	0·1349	883	56·28	0·1433
60	908	59·51	0·1594	871	54·75	0·1680	832	49·96	0·1785
70	855	52·77	0·1932	821	48·64	0·2039	787	44·71	0·2155
80	807	47·01	0·2296	777	43·57	0·2414	747	40·27	0·2541
90	765	42·25	0·2672	738	39·31	0·2806	710	36·39	0·2957
100	726	38·04	0·3082	702	35·56	0·3225	677	33·09	0·3388
110	692	34·56	0·3497	669	32·29	0·3671	647	30·21	0·3838
120	660	31·44	0·3949	640	29·57	0·4122	619	27·66	0·4318
130	631	28·74	0·4418	613	27·13	0·4599	594	25·47	0·4806
140	605	26·42	0·4897	588	24·96	0·5101	570	23·45	0·5335
150	581	24·36	0·5398	565	23·03	0·5623	549	21·76	0·5859
160	558	22·47	0·5940	544	21·36	0·6158	529	20·20	0·6416
170	538	20·89	0·6471	524	19·82	0·6726	510	18·78	0·7006
180	518	19·36	0·7060	506	18·48	0·7305	...	...	...
190	500	18·05	0·7654	...	...	...	...	...	...
200	...	...	...	...	...	...	...	...	...
210	...	...	...	...	...	...	...	...	...

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Table V. (continued).

Range.	Muzzle velocity = 1200 f.s.			Muzzle velocity = 1100 f.s.			Muzzle velocity = 1000 f.s.		
	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.	Remaining velocity.	Striking energy.	Time of flight.
Yards.	f.s.	ft.-lbs.	Seconds.	f.s.	ft.-lbs.	Seconds.	f.s.	ft.-lbs.	Seconds.
10	1099	87·22	0·02622	1018	74·74	0·02832	935	63·10	0·03102
20	1017	74·61	0·05467	950	65·13	0·05899	878	55·64	0·06434
30	950	65·13	0·08489	892	57·44	0·09126	828	49·48	0·09947
40	891	57·31	0·1179	840	50·93	0·1262	783	44·26	0·1370
50	840	50·93	0·1521	794	45·50	0·1629	743	39·85	0·1762
60	794	45·50	0·1888	753	40·93	0·2015	707	36·08	0·2173
70	752	40·82	0·2284	716	37·00	0·2421	674	32·79	0·2609
80	715	36·90	0·2693	682	33·57	0·2854	614	29·93	0·3065
90	682	33·57	0·3114	651	30·59	0·3311	617	27·48	0·3534
100	651	30·59	0·3570	623	28·02	0·3782	592	25·29	0·4026
110	623	28·02	0·4041	598	25·81	0·4259	568	23·28	0·4561
120	597	25·72	0·4539	574	23·78	0·4778	547	21·60	0·5090
130	574	23·78	0·5039	552	21·99	0·5316	527	20·04	0·5652
140	552	21·99	0·5575	532	20·43	0·5862	509	18·69	0·6218
150	532	20·43	0·6119	513	19·00	0·6440	...	...	...
160	513	19·00	0·6697	...	...	...	...	...	...
170	...	...	...	...	...	...	...	...	...
180	...	...	...	...	...	...	...	...	...
190	...	...	...	...	...	...	...	...	...
200	...	...	...	...	...	...	...	...	...
210	...	...	...	...	...	...	...	...	...

A few words only will be necessary to point out how these tables may be made use of with advantage.

A glance at Table I. will enable the reader to select the charge he proposes firing from his gun, and will show him what muzzle velocity his shot ought to have if his cartridges are loaded with good powder; should he, however, desire a higher velocity than any given by these charges, he has only to increase his powder-charge, or diminish the weight of the shot.

The muzzle velocity having been determined, the next step is to settle what size of shot will give the best results.

If we suppose that for a wild-fowl gun the muzzle velocity is to be 1400 feet per second, the effect of using different sizes of shot will be seen, from Tables II., III., IV., and V., to be as follows:—

COMPARING THE STRIKING ENERGY PER PELLET OF SHOT.

Size of Shot.	Range.	Striking Energy per Pellet.	No. of Pellets per oz. of charge.
	yards.	ft.-lbs.	
No. 4...	70	1·509	179
B B	70	4·466	79
B B B B	70	7·484	56
S S G	70	48·64	13

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COMPARING RANGE OF SHOT.

Size of Shot.	Remaining Velocity.	Range.	Striking Energy per Pellet.	No. of Pellets per oz. of charge.
	f.s.	yards.	ft.-lbs.	
No. 4	528	70	1·509	179
B B	522	90	3·336	79
B B B B	506	110	4·453	56
S S G	506	180	18·48	13

Or, if we are dealing with punt guns, and propose having a muzzle velocity of 1700 feet per second, we can make similar comparisons.

COMPARING THE STRIKING ENERGY PER PELLET OF SHOT.

Size of Shot.	Range.	Striking Energy per Pellet.	No. of Pellets per lb. of charge.
	Yards.	ft.-lbs.	
B B	100	3·336	1264
B B B B	100	5·809	896
S S G	100	43·23	208

COMPARING RANGE OF SHOT.

Size of Shot.	Remaining Velocity.	Range.	Striking Energy per Pellet.	No. of Pellets per lb. of charge.
	f.s.	yards.	ft.-lbs.	
B B	522	100	3·336	1264
B B B B	512	120	4·559	896
S S G	505	200	18·41	208

It must be borne in mind that the muzzle velocities given in Table I. are only to be obtained when the cartridges are loaded with good powder; and when cartridges are bought filled, they do not always contain powder of the best quality.

An examination of the results of experiments with 12-bore guns (*see* paper in "Proceedings, Royal Artillery Institution," No. 6, Vol. XII.) will show how poor a class of powder is sometimes supplied to the sportsman; and under the present system we must always be liable to have inferior ammunition supplied to us.

There would appear to be no reason why (should the customer require it) all loaded cartridges should not have the muzzle velocity which they are guaranteed to give marked on them, in the same way as the size of the shot is now given on the wad. There is nothing new in this proposal, as in the United States, for some time past, the muzzle velocity (found by testing a sample) which the cartridges should give has been printed on the packets of cartridges issued to the troops.

Would it not be more satisfactory to the sportsman, when he starts for a day's shooting, to know that his cartridges are loaded with the best powder, and not with trash?

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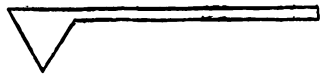
LAYING GUNS.

BY

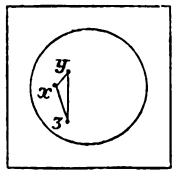
CAPTAIN C. S. B. PARSONS, R.A.

THE following is a description of an easy method, long in use in the Egyptian Artillery, for teaching recruits the use of the sights, and how to lay a gun fairly accurately. For its simplicity it may be commended.

A wooden 3 feet square target with a white bull's-eye of 2 feet diameter, and a wooden equilateral triangle (6-inch side) with a handle is all that is required—the shape of triangle and handle being thus :—



Two men are required for aiming drill—one (A) at the gun, and the other (B) at the target, which is placed at the commencement of the tuition about 60 yards from the gun. B, standing at the target, takes the wooden triangle and places it at random anywhere on the white bull's-eye, say at x, that is to say, the apex of the triangle is at x. A then lays the gun on the apex of the triangle (x). The gun now is not to be moved again. It remains in this position, *i.e.*, laid on x, which is marked off in pencil by B. B then removes the wooden triangle, and places it again anywhere at random on the white bull's-eye. A's object now is to direct B to so move the wooden triangle as to get the apex again on x; but he probably fails, and eventually instructs B to mark off a second time, and this time probably the spot is not exactly x, but a spot adjacent to x, say y. B, under instructions from A, repeats the above until a third point is marked adjacent to x, say z. A triangle, $x\ y\ z$, is now formed, which is the representative triangle of the result of the three shots, so to speak.



Those who make the smallest triangles have proved themselves to be the best shots at practice.

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HEAVY GUN PRACTICE.

BY

MAJOR D. D. T. O'CALLAGHAN, R.A.

PRACTICE, unless conducted with the utmost forethought and care, soon degenerates into shooting at a mark. It should be the endeavour of every Commanding Officer to guard against such a state of things.

In the instructions at the commencement of Practice Reports (Army Form B 80), we are told that "the main object of practice is the instruction of officers, non-commissioned officers, and men." Now, without taking direct exception to this statement, it may be contended that the annual expenditure of ammunition has a far higher value than this phrase implies.

Practice should be the outcome of all the instruction that has gone before, the coping-stone, in fact, of the structure which should have been carefully built up, course by course, the foundation being the elementary teaching that the recruit received in the working of the gun he is now permitted for the first time to fire.

An Officer in command of a District, Fort, or Battery should have two main objects always in view, viz.: the efficiency of his men and the efficiency of his guns. The latter is entirely dependent on the former.

The improved Heavy and Siege Artillery, now known as new type guns, have necessarily added to the importance of the garrison gunner, and the establishment of a practice camp at Dungeness, for which the Batteries are prepared by a course of instruction in siege operations at Chatham, has acted as a powerful stimulus to this branch of the Regiment, and has given to its members a zest for, and a pride in their work, which, it must be confessed, was somewhat lacking before.

With such encouragement, with the knowledge that the worth of their Arm is acknowledged, individual Officers will vie with each other in making the men under them good and skilful gunners.

As regards preliminary instruction. It will be admitted by all who have tried it that nothing is so irksome both to instructor and pupil as the miserable system of trying to din into the apathetic or frightened recruit, cumbrous definitions, clothed in language which is Greek to him, but which, by a painful effort, he at last learns to repeat like a parrot, without having the foggiest idea of their meaning.

Merely let the instructor *translate* the definitions, and show his pupil the *why* of them, and he will see the apathy vanish, and find that nine

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out of ten men are both willing and anxious to learn. Let him illustrate his instructions with homely similes, and he will find that his class not only understand his teachings, but remember them.

It is quite possible to teach men the general principles of gunnery without frightening them at the onset with such words as "trajectory," "parabola," or even "intersection;" but such high-flown expressions slip easily from the tongue of the smart corporal, who has acquired their sound with perhaps but vague ideas of their actual meaning. Above all things, avoid that terrible phrase, the pride of the assistant instructor, "vis inertiæ." "Weight" is shorter and simpler, and means practically the same thing,

There is no royal road to "gunner-making," so standing gun drill, though monotonous, is necessary in order to smarten the men and make them quick and precise in their movements. But even this may be made more or less attractive by conversational instruction during the "stand easy" periods; not dwelling too long on what particular *order* of lever is involved in traversing, elevating, or what not, but telling the number applying his handspike why he is told to use it in one particular way, and what he gains by so doing.

As a general rule, the gun proper and the theories pertaining to it should be avoided in these short discursive lectures; they are subjects better handled in the barrack room, when the instructor can have the aid of a black-board,—a graphical representation, no matter how rough, is worth all the talking in the world,—but the carriage and simpler parts of its fittings, such as the elevating gear, the tackles employed for running back or traversing, wheel-purchases, &c., all these afford ample materials for these brief intervals.

Let the instructor try to teach men the great mechanical principles involved in these appliances in simple, terse language, ask frequent questions during the explanations, passing from man to man like a form at school when the answer is not forthcoming, and he will soon be able to gauge the value of his own teaching, and will, moreover, get up a very wholesome spirit of emulation among his men.

In the more serious classes of instruction held in the barrack-room, the men should be taught by the use of plain, simple language, the theory of the explosive force of gunpowder, its effect on the shell, the path of the latter, the object of gas-checks, the necessity for giving elevation and deflection, and the cause and force of recoil: this last-named subject is important, as it involves the consideration of hydraulic buffers and other expedients of a like nature.

Ammunition should also be dealt with, its construction explained and illustrated by diagrams, the various effects of common, shrapnel, and Palliser shell, and the suitability of each to the peculiar work assigned to it; the general principles of fuzes, both time and percussion, *without going too deeply into manufacturing details.*

Laying should be a subject for instruction in the barrack-room and on the drill-ground, and the Officers should remember that while they have probably been in the habit of using guns and rifles from their boyhood, the chances are that the recruit has not, and should be proportionately patient.

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First lessons cannot be too elementary: it is better to suppose even that the expression "getting three points into line" is unintelligible to the recruit, and indeed, in many cases, the assumption will be literally correct. Lay the gun for him: he will see that its general direction is towards the target: throw it out of line and he will appreciate the change. Re-lay the gun, show him that now the foresight, seen through the notch in the hindsight covers the centre of the target, and he will understand what has been done, although from natural slowness and nervousness he will be unable at first to do it for himself. Remember that now, for the first time perhaps, he is called upon to think and act for himself, and this before an officer, a sergeant, and his own comrades, and it will be easy to realize and make allowances for his timidity.

As the recruit gets used to this novel use of his eyesight, he will begin to be interested in all things connected with the sighting of the gun, and then,—*and not till then*,—teach him, with the minimum amount of mathematics, and the maximum amount of patience, the meaning of degrees, and the use of the various graduations on the tangent-bar. The deflection-leaf should be the subject of *carefully thought-over* explanation.

There is one point which cannot be too firmly insisted upon, and that is the necessity, apart from its being an order, for using a full sight.

The expression "imaginary line" should be avoided, but let the recruit move his head from right to left and from left to right when looking over a gun laid with a full sight, and he will see that the point of the foresight travels along a line joining the top corners of the notch.

A large diagram on the black-board will much assist him in understanding this. As an additional reason for insisting on a full sight, it should now be impressed on him, and shown by actual experiment, that by this, and by no other method, can two or more men lay precisely alike;—a point of the utmost importance.

The instructional target recently introduced, is of great assistance to the instructor, and the men should be frequently practised with it, until they can lay a gun rapidly and accurately.

Before carrying out practice, the men should be instructed in preparing ammunition, every man having a hand in making up a cartridge and filling a shell, and before commencing firing the nature of the projectile and its particular sphere of usefulness should again be described.

The practice itself should be carried out as much as possible under Service conditions. Tackles should be properly rigged in powder and shell lifts, and as much attention bestowed on the numbers manning them as on those round the gun.

Should the target be only a barrel at sea (the most uninstructive

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form of practice), as much as possible should be made of it. Its range should be carefully ascertained by the means at the disposal of the Officer in command, and its position thus found, verified by the practice. The N.-C. officers and men should be shown that the yard-scale on their tangent-bars is only an approximation, and that the shooting will vary with the brand of powder, the force and direction of wind, and the state of the atmosphere. When firing shrapnel shell, it should be explained why it is desirable to burst the shells at such-and-such a distance short of the target and at so many feet above the plane: if the practice is over water the men will see for themselves the range and spread of the bullets.

Men should be *encouraged* to estimate the distances of bursts or grazes from the target, and not held up to ridicule when they make, as nine men out of ten will, a very bad guess.

To sum up, one great principle should underlie all practice. Its object should be to familiarize the men with their weapon, rather than to destroy the target, and this can only be attained by careful previous training.

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RIFLES FOR LARGE GAME.

THE TRAJECTORIES, TIME OF FLIGHT, REMAINING VELOCITIES, AND STRIKING ENERGIES OF BULLETS FIRED FROM LARGE BORE AND EXPRESS RIFLES.

BY

MAJOR W. McCLINTOCK, R.A.,

Assistant Superintendent, Royal Small Arms Factory, Enfield.

TO ANYONE who is about to purchase a battery of rifles for large game shooting, it will no doubt be interesting to know the trajectories, and smashing power (striking energy), which the bullets fired from such rifles have, when suitable charges are used. It is with the object of supplying such information that the following tables have been drawn up, which give the remaining velocity, the striking energy, time of flight, and heights of trajectory for intervals of twenty-five or twenty yards, up to a range of 150 yards. The heights of trajectory for 100 yards range have also been given.

In addition to the heights of the trajectories given in the tables, diagrams of the curves have also been drawn, having the heights exaggerated for the sake of clearness—the height being given on the scale of 2 inches to the foot, and the range on the scale of 2 inches to 20 yards (see Plates I. and II.).

From the two heavy rifles (4 and 8 bore) both conical and spherical bullets were fired, so the reader can form his own opinion as to the relative merits of these projectiles.

The observed velocities were found by means of the Boulengé chronograph, and the muzzle and remaining velocities, times of flight, and heights of trajectory, were calculated with the aid of Professor Bashforth's tables.

Curtis and Harvey's "treble strong" powder was used for all the charges (Martini-Henry cartridges excepted), No. 7 powder for the 4-bore rifle, and No. 6 for the other calibres.

Although the Martini-Henry rifle was not designed for sporting purposes, similar information respecting its power is given. In order to estimate the superiority of the Martini-Henry rifle, the comparison should have been made with a greater range than 150 yards.

The accuracy of rifle bullet trajectories calculated by means of Professor Bashforth's tables has been tested by firing a large number of rounds through paper screens placed at different points along the range. The rifle used in the experiment was the Martini-Henry, and the screens were erected at intervals along a 500 yards, and a 1000

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yards range. The result of the experiments was most satisfactory, the mean heights of the bullet holes in the screens agreeing closely with the heights found by calculation.

In October, 1883, this experiment was repeated by the Editor of the *Field*, with express rifles, made by Messrs. Holland & Holland. The paper screens were placed at intervals of 25 yards along a range of 150 yards, and the rifles used were the 0·577-inch, 0·50-inch, 0·45-inch, and 0·40-inch bores. Five rounds were fired from each rifle, when the mean height of the bullet holes in each screen was taken as the correct height of the trajectory at each point. The velocities of the bullets fired from these rifles was afterwards taken, and their trajectories calculated, and diagrams showing both the calculated curves and those due to the measurements are now given, the latter being represented by dotted lines. It will be noted that the measured heights (in each instance) at the two first and two last screens give points in symmetrical curves, while those of the two centre screens (at 75 and 80 yards) are about half an inch too high, and this can only be due to some error in recording the heights at these two screens (see Plate II.).

The writer is only responsible for having correctly drawn the experimental trajectories from the measurements supplied to him, as he was not present when the experiment took place, but he afterwards took the velocities of the rifles and calculated their curves.

TABLE GIVING PARTICULARS AS TO WEIGHTS OF ARMS, CHARGES, &c.

Maker.	Arms.	Weight.	Length of Barrel.	Charge.		Proportion of weight of powder to weight of bullet.	Muzzle Velocity.	Recoil.
				Powder.	Bullet.			
		lb. oz.	in.	grs.	grs.		f.s.	ft.-lbs.
J. & W. Tolley	4-bore single barrel elephant rifle	20 0	$25\frac{1}{8}$	328·08 or 12 drs.	1882 conical	1 : 5·73	1330	117·0
					1250 spherical	1 : 3·81	1460	67·35
"	8-bore double barrel elephant rifle	16 4	26	273·4 or 10 drs.	1257 conical	1 : 4·59	1500	85·37
					862 spherical	1 : 3·15	1654	53·08
"	0·45-in. double barrel express rifle	10 0	26	150·37 or $5\frac{1}{2}$ drs.	274 conical	1 : 1·822	2000	15·42
"	10-bore double barrel smooth-bore jungle gun	10 2	$25\frac{3}{4}$	136·7 or 5 drs.	698 spherical	1 : 5·106	1316	30·98
R. S.-A. F....	0·45-in. single barrel Martini-Henry rifle	9 0	$33\frac{3}{16}$	85 R.F.G.^{2}	480 conical	1 : 5·64	1315	16·6
Holland & Holland ...	0·577-in. double express rifle ...	11 10	26	164 or 6 drs.	591 conical	1 : 3·6	1663	34·1
"	0·50-in. double express rifle.....	9 1	28	138 or 5 drs.	444 conical	1 : 3·22	1784	29·27
"	0·45-in. double express rifle	8 4	26	110 or 4 drs.	322 conical	1 : 2·92	1776	17·19
"	0·40-in. double express rifle	7 14	26	82 or 3 drs.	209 conical	1 : 2·55	1874	8·814
Jeffries ...	0·50-in. double express rifle.....	8 $4\frac{1}{2}$	28	138 or 5 drs.	342 conical	1 : 2·47	1946	24·41

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0·577-INCH DOUBLE EXPRESS RIFLE (MESSRS. HOLLAND & HOLLAND).

Range.	Velocity.	Striking Energy.	Time of Flight.	Height of Trajectory.	
				For 150 yards.	For 100 yards.
yards.	f.s.	ft.-lbs.	seconds.	inches.	inches.
At muzzle	1663	3625	0	0	0
25	1594	3332	0·04623	2·3448	1·3476
50	1527	3056	0·09418	3·9108	1·8732
75	1463	2806	0·1440	4·5840	1·4772
100	1400	2569	0·1971	4·2504	0
125	1341	2357	0·2519	2·7684	...
150	1286	2169	0·3088	0	...
Highest point of trajectory				4·6068	1·8756

0·500-INCH DOUBLE EXPRESS RIFLE (MESSRS. HOLLAND & HOLLAND).

Range.	Velocity.	Striking Energy.	Time of Flight.	Height of Trajectory.	
				For 150 yards.	For 100 yards.
yards.	f.s.	ft.-lbs.	seconds.	inches.	inches.
At muzzle	1784	3134	0	0	0
25	1712	2887	0·01270	2·0148	1·15872
50	1641	2653	0·08798	3·3816	1·6188
75	1573	2436	0·1346	3·9600	1·2636
100	1507	2237	0·1832	3·6696	0
125	1443	2051	0·2340	2·3916	...
150	1382	1939	0·2869	0	...
Highest point of trajectory				3·9768	1·6212

0·45-INCH DOUBLE EXPRESS RIFLE (MESSRS. HOLLAND & HOLLAND).

Range.	Velocity.	Striking Energy.	Time of Flight.	Height of Trajectory.	
				For 150 yards.	For 100 yards.
yards.	f.s.	ft.-lbs.	seconds.	inches.	inches.
At muzzle	1776	2254	0	0	0
25	1696	2055	0·01301	2·0772	1·18656
50	1618	1869	0·08847	3·4922	1·6644
75	1543	1700	0·1358	4·1244	1·3116
100	1470	1544	0·1858	3·8436	0
125	1400	1400	0·2383	2·5128	...
150	1335	1274	0·2929	0	...
Highest point of trajectory				4·1436	1·6680

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0·400-INCH DOUBLE EXPRESS RIFLE (MESSRS. HOLLAND & HOLLAND).

Range.	Velocity.	Striking Energy.	Time of Flight.	Height of Trajectory.	
				For 150 yards.	For 100 yards.
yards.	f.s.	ft.-lbs.	seconds.	inches.	inches.
At muzzle	1874	1628	0	0	0
25	1772	1455	0·04134	1·9596	1·10376
50	1675	1300	0·08472	3·3060	1·5516
75	1581	1159	0·1311	3·9396	1·2252
100	1492	1032	0·1795	3·7164	0
125	1406	916·0	0·2315	2·4684	...
150	1326	814·9	0·2867	0	...
Highest point of trajectory	... ...			3·9720	1·5552

0·500-INCH DOUBLE EXPRESS RIFLE (MR. JEFFRIES).

Range.	Velocity.	Striking Energy.	Time of Flight.	Height of Trajectory.	
				For 150 yards.	For 100 yards.
yards.	f.s.	ft.-lbs.	seconds.	inches.	inches.
At muzzle.	1946	2872	0	0	0
25	1846	2584	0·03967	1·7004	1·01388
50	1750	2323	0·08139	3·0192	1·4244
75	1658	2085	0·1254	3·5844	1·12872
100	1569	1867	0·1720	3·3696	0
125	1484	1671	0·2210	2·2368	...
150	1402	1490	0·2734	0	...
Highest point of trajectory	... ...			3·6108	1·4292

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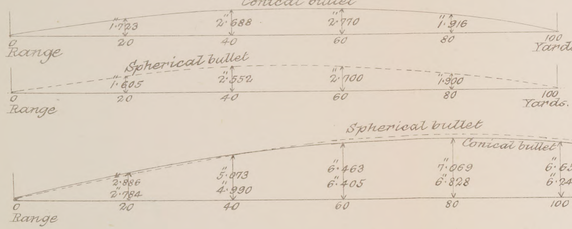
PLATE I. TRAJECTORIES OF SPHERICAL AND CONICAL BULLETS.

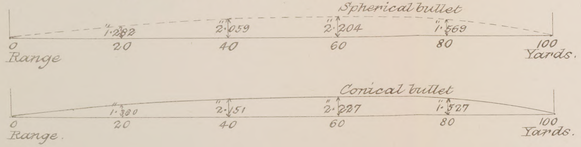
MESSRS. J & W. TOLLEY.

Single barrel elephant rifle, 4 bore.



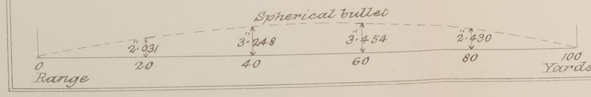
Messrs. J. & W. Tolley.	Range.	Velocity.	Striking Energy.	Time of Flight.	Heights of Trajectory. 150 Yards Range.	Heights of Trajectory. 100 Yards Range.
	Yards.	f.s.	ft. lbs.	Seconds.	Inches.	Inches.
4-Bore Conical Bullet of 1882 grains; Powder, 12 drams	At muzzle.	1330	7387	0	0	0
	20	1293	6981	0·04516	2·8830	1·7232
	40	1257	6597	0·09208	5·6736	2·8880
	60	1223	6244	0·1413	6·4056	2·7708
	80	1191	5923	0·1908	6·8280	1·9164
	100	1160	5619	0·2428	6·3472	0
	120	1131	5342	0·2954	4·5936	
	140	1104	5088	0·3485	1·8516	
	150	1091	4969	0·3760	0	
4-Bore Spherical Bullet of 1250 grs. Powder, 12 drams.	At muzzle.	1460	5912	0	0	0
	20	1375	5242	0·04234	2·7840	1·6056
	40	1296	4659	0·08744	4·9908	2·5524
	60	1224	4155	0·1349	6·4632	2·7000
	80	1158	3718	0·1854	7·0692	1·9008
	100	1099	3351	0·2385	6·6516	0
	120	1047	3039	0·2946	5·0208	
	140	1001	2777	0·3538	1·9812	
	150	983	2669	0·3828	0	

Double barrel elephant rifle, 8 bore.



Messrs. J. & W. Tolley.	Range.	Velocity.	Striking Energy.	Time of Flight.	Heights of Trajectory. 150 Yards Range.	Heights of Trajectory. 100 Yards. Range.
	Yards.	f.s.	ft. lbs.	Seconds.	Inches.	Inches.
8-Bore Conical Bullet of 1257 grains; Powder, 10 drams	At muzzle.	1500	6273	0	0	0
	20	1461	5870	0·04032	2·3400	1·3800
	40	1403	5487	0·0825	4·1172	2·1516
	60	1357	5135	0·1261	5·2308	2·2272
	80	1313	4807	0·1714	5·8124	1·6376
	100	1272	4511	0·2175	5·1792	0
	120	1233	4237	0·2652	3·8724	
	140	1196	3989	0·3150	1·5696	
	150	1178	3870	0·3408	0	
8-Bore Spherical Bullet of 862 grains; Powder, 10 drams	At muzzle.	1654	5232	0	0	0
	20	1546	4569	0·03736	2·2548	1·2832
	40	1446	3998	0·07741	4·0704	2·0592
	60	1354	3505	0·1203	5·3400	2·2044
	80	1270	3084	0·1662	5·9016	1·5696
	100	1193	2720	0·2151	5·6052	0
	120	1125	2419	0·2685	4·2996	
	140	1065	2169	0·3213	1·7820	
	150	1038	2059	0·3500	0	

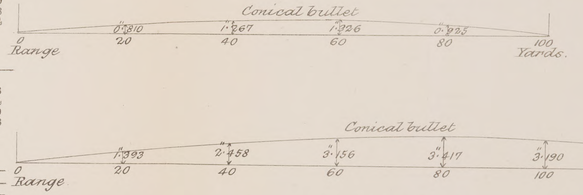
Smooth bore double barrel jungle gun, 10 bore.



Messrs. J. & W. Tolley.	Range.	Velocity.	Striking Energy.	Time of Flight.	Heights of Trajectory. 100 Yards Range.
	Yards.	f.s.	ft. lbs.	Seconds.	Inches.
10-Bore, Double Barrel, Smooth-Bore, Jungle Gun, (Spherical Bullet). Powder, 5 drams. Bullet, 698 grains.	At muzzle.	1316	2681	0	0
	20	1226	2328	0·04731	2·0316
	40	1146	2033	0·0980	3·2484
	60	1077	1797	0·1515	3·4548
	80	1017	1601	0·2096	2·4300
	100	966	1445	0·2693	0

MESSRS. J & W, TOLLEY.

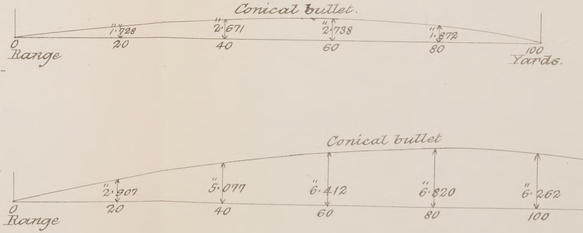
Double barrel express rifle, 0·45 in. bore.



Messrs. J. & W. Tolley.	Range.	Velocity.	Striking Energy.	Time of Flight.	Heights of Trajectory. 150 Yards Range.	Heights of Trajectory. 100 Yards Range.
	Yards.	f.s.	ft. lbs.	Seconds.	Inches.	Inches.
0·45-in., Double Barrel, Express Rifle (Conical Bullet). Powder, 5½ drams. Bullet, 274 grains.	At muzzle.	2000	2431	0	0	0
	20	1917	2234	0·03663	1·3932	0·8100
	40	1837	2051	0·08256	2·4588	1·2672
	60	1759	1880	0·09612	3·1560	1·3260
	80	1684	1724	0·1309	3·4176	0·92568
	100	1611	1578	0·1675	3·1908	0
	120	1541	1443	0·2053	2·4108	
	140	1473	1317	0·2456	0·97248	
	150	1439	1258	0·2661	0	

R. S. A. F.

Martini-Henry rifle, 0·45 in bore.



Royal Small Arms Factory.	Range.	Velocity.	Striking Energy.	Time of Flight.	Heights of Trajectory. 150 Yards Range.	Heights of Trajectory. 100 Yards Range.
	Yards.	f.s.	ft. lbs.	Seconds.	Inches.	Inches.
0·45-in., Single Barrel, Martini-Henry Rifle (Conical Bullet). Powder, 85 grains. Bullet, 480 grains.	At muzzle.	1315	1841	0	0	0
	20	1283	1752	0·04555	2·9076	1·7280
	40	1252	1669	0·09287	5·0772	2·6712
	60	1222	1590	0·1419	6·4128	2·7384
	80	1194	1518	0·1911	6·8208	1·8720
	100	1167	1450	0·2418	6·2628	0
	120	1141	1387	0·2944	4·6356	
	140	1116	1326	0·3484	1·8516	
	150	1104	1297	0·3759	0	

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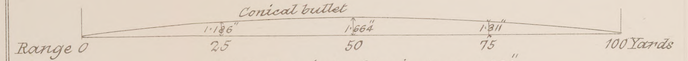
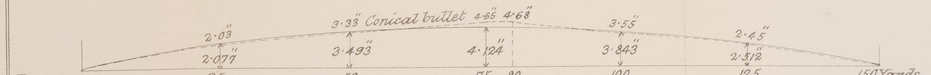
PLATE II. GIVING TRAJECTORIES DUE TO MEASUREMENTS AT THE "FIELD TRIAL", AND ALSO THE CALCULATED TRAJECTORIES.

MESSRS HOLLAND & HOLLAND.
0·45" double express rifle.

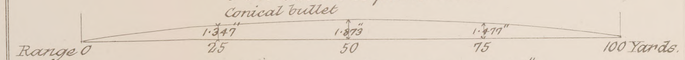


Highest point of trajectory = 1·668"

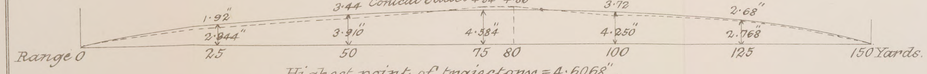


Highest point of trajectory = 4·1436"

0·577" double express rifle.

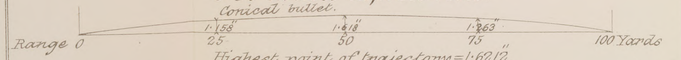


Highest point of trajectory = 1·8756".

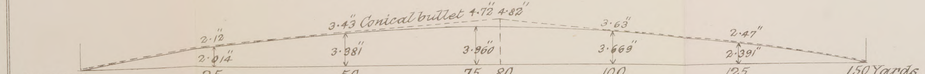


Highest point of trajectory = 4·6068"

0·50" double express rifle.

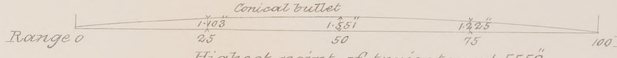


Highest point of trajectory = 1·6212"

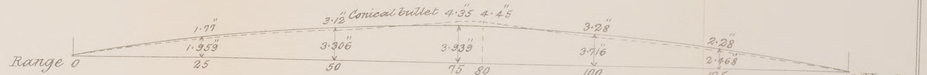


Highest point of trajectory = 3·9768"

MESSRS HOLLAND & HOLLAND.
0·40" double express rifle.

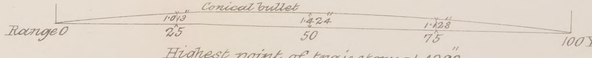


Highest point of trajectory = 1·5552"

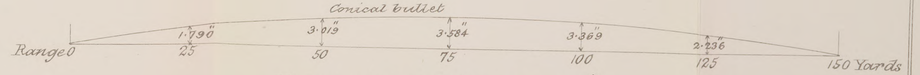


Highest point of trajectory = 3·972".

MR JEFFRIES'.
0·50" double express rifle.



Highest point of trajectory = 1·4292".



Highest point of trajectory = 3·6108".

NOTE. Dotted lines and figures the results of measurements.
Black ___ do _____ do _____ do ____ calculations.

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NOTES

ON

INTERIOR ECONOMY OF NATIVE MOUNTAIN BATTERIES.

BY

CAPTAIN J. D. DOUGLAS, R.A.,

Commandant No. 1 (Bombay) Mountain Battery.

SOME time ago I thought of sending a few notes on Mountain Batteries, but doubted whether the subject possessed sufficient general interest to warrant my doing so. Captain Keene, in the number of this Journal for December, 1883, has to a certain extent forestalled me, but at the same time rendered my task easier by introducing the subject. I could add little to the information he gives as applicable to both Native and British Mountain Artillery, and the following notes are therefore only an attempt to complete his paper as regards Native Batteries of Mountain Artillery. Perhaps some of my hints may prove useful not only to young Officers of Native Batteries, but to others who may, with comparatively little Indian experience, find themselves unexpectedly in command of detachments of Native Troops.

ESTABLISHMENT.

The *personnel* of a Native Mountain Battery on a war strength of six guns consists of 1 Captain and 3 Lieutenants of Royal Artillery, and 230 Native Artillery of all ranks, Native officers, N.-C.-officers, gunners, drivers and trumpeters. There are 2 Native officers (it is proposed to increase the number to 3 in future for 6-gun Batteries), and 2 staff havildars, answering to Sergeant-Major and Quarter-Master-Sergeant. The gunner establishment of each subdivision is 1 havildar, 1 naik (or corporal), 1 lance naik, and 12 gunners. The driver establishment is so far separate that there are driver N.-C.-officers. The ranks of driver havildar and naik are unnecessary so far as the discipline of the Battery is concerned, but it is impossible to make drivers into gunner N.-C.-officers, where detachments must be not only tall but level in height, and the grades are rightly maintained as legitimate rewards for deserving drivers.

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Officers.

The Captain, styled officially Commandant, has the status, as regards discipline, of the Commandant of a Native Regiment. The Subalterns have each charge of a Division. It rests to a certain extent with the Commandant to determine how far their charges are separated. As the experience of Frontier campaigns tends to show that Divisions on service are more frequently detached than together, it is obviously desirable that they should have every opportunity of acquiring habits of independent command. The Captain receives staff allowance of ₹300 a month with the Staff Corps pay of his rank. Subalterns are allowed ₹150 Staff, and Regimental pay. These rates include horse allowance.

Native Officers.

Native officers rise from the ranks. The extent to which they are entrusted with assisting in interior economy rests with the Commandant, subject to the consideration that their status must be kept, in the eyes of the men, equivalent to that of the corresponding ranks in the Cavalry and Infantry. Seeing all Troop and Company officers in these branches are Natives, the preservation of their dignity, coupled with the keeping of the actual command of Divisions in the hands of the Subaltern officers, requires the exercise of a little tact. Their duties in action and on the line of march are not defined by regulation. Ample and responsible employment can be found for them in the charge of the second line of ammunition and the baggage column, as the fighting or manœuvring line of a Battery contains less than one fourth of the establishment of "Ordnance" mules, and only one sixth of the ordnance and baggage mules combined. Their pay is the same as that of corresponding ranks in the Infantry, and they are mounted, on ponies, by the State.

N.-C. Officers and Men.

N.-C. officers and gunners are paid rather more than the corresponding ranks in the Infantry, N.-C.-officers of drivers rather less, drivers the same. Some anomalies with regard to the driver establishment, due to these men having formerly been of the "follower" class, exist; but the general principle is that drivers are paid as sepoys, and gunners rather better, with a view, in the latter case, to obtaining bigger men than in the Infantry. There are 2 trumpeters, paid as gunners, and mounted. Artificers are not "fighting men."[1]

Discipline.

The Battery is governed by the Indian Articles of War. The scale of minor punishments is framed under these Articles by the Commander-

[1] I use the term "fighting men" as used in the Pay and Commissariat Codes (of India). It is not synonymous in every case with "combatant," nor does it always comprehend enlisted followers, *e.g.*, Store Lascars and some classes of Hospital Servants are non-combatant fighting men.

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in-Chief, and published in the Army Regulations of the three Presidencies. Officers occasionally join Native Batteries with but a hazy idea of the difference between the Army Act and the Indian Articles of War. Instruction in the latter demands special attention, as in a well disciplined Battery there is frequently so little serious crime that an Officer may serve some time without feeling the effects of his ignorance practically.

Language.

The official language between Officers and men is Hindustani. Words of command are given in English, but instructions and explanations in Hindustani. The linguistic qualification required from Officers is the Hindustani Higher Standard Examination. Officers may be, and are, appointed on having passed the Lower Standard only, and in this case are allowed a year's probation in which to pass the higher standard.

Pay and Accounts.

Pay is drawn and issued monthly in arrears. Rations are not issued except on Field Service. There is, however, an ideal ration which the Native soldier is supposed to consume. When the cost of this ration at the Station exceeds ₹3 8a. a month, the difference is paid to the soldier as "compensation for dearness of provisions," or "grain compensation." The calculation of this item on the Pay Sheet is simple enough at Battery Head Quarters, but sometimes gives a good deal of trouble when men are detached. For instance, a Battery at Quetta, where free rations are issued, may send a man for duty to a Battery at Poona, the man may be detained by floods in the Bolan, be taken sick at Jacobabad, and have to wait at Kurrachee for a Government steamer. This, I may remark, is *not* an ideal case. While on board ship he receives free rations, and is not entitled to grain compensation. Extra *batta* is issued to a Native soldier, while marching, unprovided with public carriage. This allowance, although less troublesome than grain compensation, also gives some trouble under similar circumstances. I can give no infallible rule for keeping these accounts straight, but the best plan is to call for detachment muster rolls from every Officer under whose temporary command the man or party is supposed to have passed. These documents are seldom sent unless asked for, nor is, I believe, any Officer bound to furnish them unless he happens to be the mustering Officer of the party.[1] The rest of the pay accounts are as simple as can be desired. The Regulation Funds kept in a Battery are the Grass, Hutting, and School Funds, none of which call for special notice.

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[1] The difficulty of course only exists when a party moves unaccompanied by an Officer, or a N.-C.-officer capable of keeping a rough route in writing.

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Clothing and Necessaries.

It is desirable to keep up a Clothing or Necessaries Fund, especially when a Battery is serving on or beyond the Frontier; although, theoretically, the Native soldier is bound to keep himself clothed as well as fed without trouble to his officers. The only clothing issued by Government is one cloth Norfolk jacket, and one serge knickerbockers with putties, biennially; recruits being provided with part worn clothing stored by the Battery. Each recruit receives an allowance of ₹30 on joining, and each soldier, after two years service, ₹4 annually towards keeping up his kit. Great coats, khakee clothing, turbans, shoes, bedding and underclothing have to be kept up by the soldier, aided by the above grants. The best plan I know of, although a somewhat troublesome one, is to make these grants the nucleus of a fund, and to keep a debtor and creditor account between the fund and the soldier during the whole of his service. A prosperous fund will support a tailor's shop, and sewing machines, and pay ready money for khakee drill, &c., thus materially benefitting the soldier and securing uniformity of equipment.

Soldiers' Records.

The whole particulars of a native soldier's service are contained in his "Sheet Roll." These documents are kept in the Battery office. They contain, on the first page, descriptive roll, dates of enlistment and promotion, record of war or other special services; on seven succeeding pages, register of furlough, defaulter's sheet, hospital register, next of kin and heir rolls; and on the last page, final settlement of accounts with soldier or his heir on the termination of his service. The preparation and custody of these documents demand close personal supervision, and it is well to note the relative importance of the entries and the extent to which they can be checked or revised if necessary. A recruit on joining from his native village arrives with descriptive roll signed by a Medical and a Staff or Regimental Officer. This document gives the opinion of these Officers as to his fitness for service and identifies the recruit. But as its heading has probably been made made out, at the instance of the recruiting havildar, by any native clerk willing to oblige the latter, its spelling will generally be found more ingenious than correct. The following particulars must be carefully entered: name, father's name, tribal designation and religion (*e.g.*, Jat, Sikh; Awan, Mussulman), village, thāna, tehsil, zilla. The last four in the Punjab answer roughly to village, market town, hundred, county, and the names for them differ in different provinces of India. I would advise an Officer having to make these entries to read up what he can about the castes and tribes of the province in which he recruits, and to identify the villages on a map. It may seem pedantic to insist on these details, but the soundness of my advice will become apparent if the recruit deserts and has to be reclaimed through the Civil Power. A descriptive roll in duplicate is sent to the Assistant-Adjutant-General, R.A. (in the Bombay Presidency) for

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confirmation and record, and forms a check on the descriptive roll. The dates of promotion can be checked by the biennial roll of N.-C. Officers furnished to the A.-A.-G., R.A. The record of war service, &c., can only be checked by reference to the Battery Digest of Service. The register of furlough contains the data for deciding the soldier's claim to leave. It is difficult to check it after the lapse of some years. The Hospital Register takes the place of a Medical History Sheet, and I have little hesitation in saying that the information it contains can seldom be recovered in a Native Battery if the sheet roll be lost. The case is probably different in Native Regiments, hospitals being on the regimental system. A Battery forms a subordinate or extra medical charge, and the doctor is necessarily, sometimes I think unnecessarily, changed frequently; so that if it is difficult in all cases to trace a man's medical history far back in hospital records, it is hard to say who is to blame for any particular mistake. The simplest plan of keeping the register is to have the patient's "bed-head ticket" sent to the Battery office on his discharge from hospital. Discretion may be exercised as to the necessity of entering slight cases of under seven days' duration, as no question of statistics is involved. The Battery Defaulters' Sheet can be checked by Court-Martial Sheets, which should be kept in a separate file, and the Minor Punishment Book, which takes the place in a Native Corps of the prisoners columns in written Guard Reports. The entries of next of kin and heirs should be revised every six months.

I have refrained, in the foregoing sketch of the interior economy of a Native Battery, as far as possible, from giving any opinion not thoroughly borne out by experience. I cannot, however, refrain from repeating one maxim which, although admitted theoretically by all, is not, I think, universally acted on by the Service generally in forming opinions regarding various corps. It is "The more inferior the materials out of which soldiers are to be made, the better should be the Officers called on to form and lead them." I mean to leave the application of this less to the few who may sometimes think disparagingly of "nigger" Officers, than to the subaltern who may, in leaving a smart Battery of Royal Artillery for the sake of the extra emoluments of a Native Corps, be disposed to think he is about to waste his energy, knowledge, and talent in the junior branch. One illustration, and I conclude:—We all know the best Corps in the Service is the 100th Hussars, recruited from the flower of England's light weight riders (military, not race,) the worst the 200th Tonquin Rangers, recruited from the effeminate population of that province. I should be sorry to say the Officers of the 100th were not much smarter than those of the 200th, but I might be right in thinking so. There is no moral to this fable.

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MILITARY RIFLES.

COMMUNICATED BY THE

DIRECTOR OF ARTILLERY.

THE weights and dimensions given in the following tables were obtained from examination of the arms and ammunition at the Royal Small Arms Factory, Enfield Lock.

The *observed* velocities were found by means of the Boulengé Chronograph, and the muzzle velocities, remaining velocities, and times of flight were calculated with the aid of Professor Bashforth's Tables.

TABLE I.

COUNTRIES AND SUPPOSED LATEST PATTERNS.

COUNTRY.	Supposed Latest Patterns.	Remarks.
Austria	Werndl, pattern 1873.	
Bavaria	Werder, Mauser.	
Belgium	Albini-Braendlin, pattern 1867	No samples at R.S.A.F.
Brazil	Comblain, No. 2, Westley-Richards ...	" "
China	Remington, Spencer, Snider.	
Denmark	"	
Egypt	"	
France	Gras, Chassepôt.	
Germany	Mauser.	
Great Britain	Martini-Henry, Snider.	
Greece	Gras, pattern 1874.	
Holland	Beaumont, Chassepôt (modified) ...	No Beaumont at R.S.A.F.
Italy	Vetterli (single loader and magazine).	
Japan	Murata.	
Madagascar	Remington, Snider.	
Montenegro	Krink, Dreyse	No samples at R.S.A.F.
Norway and Sweden ...	Jarmann (magazine), Remington.	
Persia	Chassepôt.	
Peru	Beaumont (modified)	No sample at R.S.A.F.
Portugal	Martini-Henry, Snider.	
Roumania	Peabody-Martini.	
Russia	Berdan No. 2, pattern 1871.	
Servia	Peabody, Grün	No samples at R.S.A.F.
Spain	Remington, pattern 1871.	
Switzerland	Vetterli (magazine).	
Turkey	Peabody-Martini.	
United States	Springfield.	

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TABLE II.

Lengths and Weights, &c.

Systems.	Calibre.	Weight.		Length.		Grooves.				Mechanism.		Proportion of weight of powder to weight of bullet.	Weight of 1 cartridge.
		Without Bayonet.	With Bayonet.	Without Bayonet.	With Bayonet fixed.	Number.	Width.	Depth.	Length of 1 turn.	Closing.	Striking.		
	ins.	lb. oz.	lb. oz.	ft. in.	ft. in.		in.	in.	in.				grains.
Berdan	0·42	9 12½	10 12½	4 5	6 1¼	6	0·16	0·011	21	Bolt	Spiral spring and firing-pin	1 : 4·743	610
Chassepôt	0·433	9 5½	10 12½	4 3½	6 2	4	0·17	0·010	22	Bolt	Spiral spring and firing-pin	1 : 4·425	492
Chassepôt (modified)	0·433	9 8½	10 6½	4 3¾	6 0	4	0·18	0·012	30	Bolt	Spiral spring and firing-pin	1 : 4·911	609
Gras	0·433	9 11	10 14½	4 3	5 11½	4	0·18	0·010	22	Bolt	Spiral spring and firing-pin	1 : 4·825	682
Jarmann (magazine)	0·397	10 1½	...	4 4½	...	4	0·16	0·010	22	Bolt	Spiral spring and firing-pin	1 : 4·37	620
Martini-Henry	0·45	9 0	9 14	4 1½	5 11½	7	...	0·007	22	Falling hinged block	Spiral spring and striker	1 : 5·65	758
Mauser	0·433	10 4	11 12	4 4¾	6 0½	4	0·18	0·012	22	Bolt	Spiral spring and firing-pin	1 : 5·066	650
Murata	0·432	9 10	11 3¾	4 3½	6 2	5	0·20	0·006	20	Bolt	Spiral spring and firing-pin	1 : 5·06	697
Peabody-Martini	0·45	9 10	10 8½	4 1	5 9	7	...	0·007	22	Falling hinged block	Spiral spring and striker	1 : 5·65	802
Remington	0·433	9 5½	10 13½	4 2¼	6 1	5	0·175	0·010	20	Segmental block	Flat spring and striker	1 : 5·33	665
Snider	0·577	9 0¾	9 11¼	4 7	6 0½	3	0·235	0·005 / 0·012	78	Turn-over block	Side lock and striker	1 : 6·857	715
Springfield	0·45	9 5¼	10 1	4 3½	5 9½	3	0·24	0·005	22	Turn-over block	Side lock and striker	1 : 7·143	752
Vetterli, single loader (Italy)	0·408	9 9	10 14½	4 5½	6 2	4	0·165	0·009	26	Bolt	Spiral spring and firing-pin	1 : 5·16	568
Vetterli, magazine (Italy) ...	0·408	10 15	11 10½	4 4¼	5 11¼	4	0·18	0·012	26	Bolt	Spiral spring and firing-pin	1 : 5·63	468
Vetterli, magazine (Swiss) ...	0·409	10 6	11 3½	4 4	5 11	4	0·18	0·009	26	Bolt	Spiral spring and firing-pin	1 : 5·63	465
Werder	0·433	9 13	11 6½	4 3¾	5 10⅓	4	0·16	0·012	36	Falling hinged block	Flat spring and striker	1 : 5·14	543
Werndl	0·433	9 13½	11 8½	4 2	6 0⅝	6	0·15	0·018	28	Revolving block	Side lock and striker	1 : 4·805	655

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TABLE III.

Velocities, &c.

Systems.	Calibre.	Length of Barrel.	Charge.		Value of $\frac{d^2}{w}$	Velocities.				
			Powder.	Bullet.		Muzzle.	At 500 yards.	At 1000 yards.	At 1500 yards.	At 2000 yards.
	inches.	inches.	grains.	grains.		f.s.	f.s.	f.s.	f.s.	f.s.
Berdan	0·42	$32\frac{3}{4}$	77·162	370	3·336	1444	873	645	476	353
Chassepôt	0·433	$32\frac{5}{10}$	87	385	3·409	1373	848	623	457	338
Chassepôt (modified)	0·433	$32\frac{3}{4}$	68	334	3·930	1369	806	566	396	281
Gras	0·433	$32\frac{1}{4}$	80	386	3·416	1489	878	643	471	348
Jarmann (magazine)	0·397	32	77	337	3·222	1536	908	675	504	377
Martini-Henry	0·45	$33\frac{3}{10}$	85	480	2·953	1315	869	664	508	389
Mauser	0·433	$33\frac{5}{8}$	75	380	3·453	1430	859	629	459	338
Murata	0·432	$33\frac{1}{8}$	83	420	3·110	1487	905	679	512	387
Peabody-Martini	0·45	$33\frac{3}{10}$	85	480	2·953	1380	888	678	519	397
Remington	0·433	$35\frac{3}{10}$	75	400	3·281	1340	849	631	468	350
Snider	0·577	39	70	480	4·855	1240	711	458	299	196
Springfield	0·45	$32\frac{1}{2}$	70	500	2·834	1301	875	676	523	404
Vetterli, single loader (Italy) ...	0·408	$33\frac{7}{8}$	62	310	3·759	1430	835	595	422	304
Vetterli, magazine (Italy)	0·408	$33\frac{3}{10}$	55	310	3·759	1389	824	588	417	300
Vetterli, magazine (Switzerland)	0·409	33	55	310	3·777	1314	804	572	406	292
Werder	0·433	35	64	329	3·989	1424	815	570	396	280
Werndl	0·433	33	77	370	3·547	1439	854	620	449	328

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TABLE IV.

Heights of Trajectory.

Systems.	Greatest Heights of Trajectory.			
	500 yards.	1000 yards.	1500 yards.	2000 yards.
	feet.	feet.	feet.	feet.
Berdan	7·995	47·01	151·7	388·7
Chassepôt	8·594	50·44	162·8	417·3
Chassepôt (modified)	9·243	56·62	193·8	528·9
Gras	7·769	46·6	151·8	389·9
Jarmann (magazine)	7·235	42·97	137·6	348·5
Martini-Henry	8·594	47·90	147·1	357·85
Mauser	8·219	48·68	159·2	411·1
Murata	7·433	43·53	137·7	341·8
Peabody-Martini	8·097	45·395	139·77	341·67
Remington	8·539	50·42	160·3	403·1
Snider	11·35	75·58	284·5	866·2
Springfield	8·574	46·88	142·3	343·0
Vetterli, single loader (Italy)	8·527	52·17	176·3	469·9
Vetterli, magazine (Italy)	8·892	53·63	181·1	484·4
Vetterli, magazine (Swiss)	9·475	57·07	191·0	510·2
Werder	8·880	54·80	190·9	523·1
Werndl	8·252	49·11	162·6	426·0

TABLE V.

Times of Flight.

Systems.	Times of Flight over different Ranges.			
	500 yards.	1000 yards.	1500 yards.	2000 yards.
	seconds.	seconds.	seconds.	seconds.
Berdan	1·409	3·418	6·139	9·826
Chassepôt	1·461	3·540	6·357	10·18
Chassepôt (modified)	1·516	3·751	6·939	11·47
Gras	1·389	3·402	6·141	9·812
Jarmann (magazine)	1·341	3·208	5·846	9·305
Martini-Henry	1·461	3·419	6·015	9·4287
Mauser	1·432	3·477	6·288	10·100
Murata	1·359	3·289	5·818	9·215
Peabody-Martini	1·4182	3·358	5·893	9·213
Remington	1·473	3·539	6·310	10·001
Snider	1·679	4·333	8·409	14·67
Springfield	1·460	3·417	5·916	9·23
Vetterli, single loader (Italy)	1·455	3·599	6·618	10·80
Vetterli, magazine (Italy)	1·486	3·651	6·708	10·97
Vetterli, magazine (Swiss)	1·534	3·765	6·889	11·26
Werder	1·486	3·690	6·887	11·40
Werndl	1·432	3·503	6·354	10·29

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BATTLE FIELDS

IN THE

LE MANS CAMPAIGN.

BY

CAPTAIN R. F. JOHNSON, R.A.

PREFACE.

THIS description of the battle fields in the Le Mans Campaign, has been written as a supplement to the accounts given in the 16th section of the German Official Account and General de Chanzy's book, in order to assist a student in a personal inspection of the ground, and to save time and trouble in the preliminary study of the movements of each side. The writer is convinced that, in default of actual experience in active warfare, it is next to impossible to obtain a correct idea of time and distance without such a personal inspection of ground that has been fought over; and knows that the preliminary study, requisite to ensure profit being derived from it, must take much time.

The ground on which Prince Frederick Charles met the most formidable and best led of the Armies of the Republic, is especially interesting to Englishmen, as it is much enclosed, and in many respects resembles that they would have to fight on in case of an invasion of their country; and the hope of inducing others to pay a visit to it must be an excuse for publishing such an imperfect work. As many Officers, especially in the Auxiliary Forces, cannot spare time for the excursion, the country is described more minutely than is necessary for a simple guide book.

No maps have been given as those of the works it is intended to supplement are sufficient, but that of the "*Service Vicinal*" is strongly recommended.

The German company has throughout been called a quarter battalion, to assist the comparison with British units.

The story is left to teach its own lessons, but attention is called to one point in the French tactics, which seems to indicate an error that the defence is very liable to in an enclosed country—the fighting in nearly every instance took place in front of and beyond the position previously chosen. It is true that towards the end General de Chanzy's aim was to gain time for his detached right to regain the grand position, but if he had not tried to strike blows really beyond his reach, he would have had no necessity to make this struggle for delay.

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In the actual combat the cause of this fatal mistake is not difficult to find. The position is occupied, and outposts are pushed in advance on the narrow lines of approach. The head of the attacking column comes into collision with one of these posts; the deployment for attack in the enclosures takes much time. The Commander of the post finding he is not immediately driven in, sends back to say, the fight is going well with him, and some reinforcements will enable him to assume the offensive successfully. This goes on for some time, the fighting line of the defence being fed faster than that of the attack, which only carries on a delaying action until its deployment is complete. Then comes the advance in overwhelming force; and the defenders, by the time they reach the proper position for fighting, are beaten troops, and are lucky if it is not carried with a rush by the assailants at their heels.

Anyone who has tried selecting a position in enclosed country, knows how one is continually tempted to push this and that part of the line a little forward to gain a field of view, and most of the battles of this campaign teach the same lesson.

The whole trip can be comfortably done in a fortnight, thus—

One night and 1st day, London to Chartres—Hotel du Duc de Chartres.
2nd " Action at La Fourche.
3rd " Chartres to Vendome—Hotel Gaillard (*late* Jonquet).
4th " Actions of Azay and Mazangé.
5th " Action of St. Amand.
6th " Vendome to Le Mans—Hotel de la Boule d'Or. Action of Chahaignes *en route*.
7th " Actions of Connerré and Thorigny.
8th " Action of Ardenay.
9th " Action of Parigné l'Evêque.
10th " Actions of Changé.
11th " Actions of Le Chêne and Les Cohernières.
12th " Action of Chateau du Loir road.
13th " Actions of St. Hubert, Champagné, and Auvours Heights.
14th day and one night, Le Mans to London.

No 1.

LA FOURCHE.

6 January, 1871.

From Chartres to Condé sur Huisne by train. As far as La Loupe the country is perfectly open, but some large forests can be seen in the distance; beyond this place an enclosed district is entered, closely resembling parts of Worcester and Hereford.

On leaving Condé station turn to the left (S.E.) and pass straight through the village leaving the church on the left; turn up hill to the left (E.) about ¼ mile beyond the village at the point where the road

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bifurcates and is joined by a small lane from the N.E. Ascend the hill, passing through the small collection of cottages called La Roulandière, and continue straight on until the main Chartres-Nogent-le-Rotrou road is reached, just by a small house, called the Café de l'Ambulance. Here there are woods N.E., E., and S.E., but S.W. there is an opening which enabled the French to make a stand at La Cour au Loup, a small group of cottages visible on its further edge. The road as yet followed, continues straight on down the S.E. slope of the ridge you are on to Marolles. Turn to the left (N.E.) along the Chartres road and continue along it, till a collection of cottages is reached at the end of the ridge; this is La Fourche, the site of two actions in the war; commemorated by a neglected monument in the fork of the roads, and by two German shells placed in the wall of a house with inscriptions above them. The main road here turns eastward, but a very good one continues straight on for La Loupe. Go a little way down the main road and into a field on the left, whence a good view of the country can be obtained.

You are on the northern extremity of a V shaped ridge, the apex of which points to the N.E. The western branch, that followed by the Nogent-le-Rotrou road, is nearly level on its summit, which is narrow, and has an abrupt slope to the westward; the other branch falls away to the south, is broader, and has less abrupt slopes; there is no very marked depression between the two branches. The summit is covered with woods, and the steep part of the western slope with heather, the remainder is cultivated land divided into fair-sized fields by large hedges, with small farms dotted here and there. The French defended the northern part of this ridge against the German advance on the 6th January with 3000 men, 6 guns, and 2 mitrailleuses. The guns were apparently placed in the fork of the roads where you are standing, and the Infantry on the crest and in the farm buildings on the slopes.

The valley in front is covered with small enclosures and orchards, divided by high hedges containing much timber, and with numerous small farms. On the right the view is bounded by an isolated ridge about 2700 yards distant, whose summit is covered with fir wood on its southern half, and with heather on the northern; the Chartres road winds round its southern end. In front, after a sharp fall of 1200 yards, the ground rises at a gentle slope to far beyond Artillery range, and is traversed in a straight line by the La Loupe road, west of which the ground falls away towards the low valley of the Corbionne river, over 2 miles on your left. The spire of Coulonges Church can be seen in a deep side-valley to your left front (N).

A better view of the whole field can be obtained on the isolated ridge to your right, to reach which go down the Chartres road. At the bend on the southern end of the ridge there is a good view of the right of the French position and the line of advance of the German left attack, which left the main road here and moved rather to the south of due east; S. and E. is the deep, narrow, and wooded valley of the Noues brook. Follow the main road half up the hill beyond the curve and then turn to the left (N.W.) into the fir wood; continue along the track until it begins to descend the western slope, and then bear to

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your right and attain the highest point of the open heather-clad end of the ridge. This is the point whence the German Artillery first opened fire in answer to that of the French, which had stopped the advance along the main road.

The valley to the front (W.) and right (N.) has already been described: in rear the Chartres road disappears round a knoll, beyond which and to the south the country is composed of ridges resembling the one you are on in every respect except that they are longer. On the left front the Chartres road is seen ascending to la Fourche, marked by two white houses on the end of the ridge, and across the front the line of the La Loupe road can be traced through the thick network of enclosures. The slopes of the ridge you are on are very steep, but the Chartres road approaches the top on the eastern side, and so renders it an excellent Artillery position for a force advancing from that direction.

On the 6th of January, 1871, the air was cold and clear, but the ground was covered with snow.

At about 9 o'clock along the main road behind you, a German column appears, consisting of 3 Battalions, 3 Squadrons, and 6 Horse Artillery guns. At its head, searching the enclosures on each side of the road, ride some Lancers, who disappear under the eastern side of the hill. All is quiet; on the opposite slopes can be seen parties of French soldiers made conspicuous by their red trowsers, cooking their morning meal. Suddenly guns at La Fourche open fire down the Chartres road; the Lancers have been seen as they turn the end of the ridge; they halt but are lucky to have got so far, for a mitrailleuse and a few rifles on your ridge would have troubled them much. The French parties quickly fall in and prepare to hold their posts. Soon the rumble of wheels can be heard, and from the fir wood on your left issues the German Battery at a gallop, and takes up a position to fire at La Fourche, distant 3250 yards. The game has commenced.

The French appear concentrated near La Fourche, and do not pay much attention to their right, which rests on thick woods, approachable by lanes from the valley of the Noues brook. Accordingly, while one of the German Battalions moves into line in the curve of the road so as to stop any hostile advance, another is despatched to the S.W. by Bouvereau to attack the French right in the woods. One Battalion remains on the road on the east of the ridge in reserve, but detaches $\frac{1}{4}$ of its strength to Marolles, the village visible on the south end of the second ridge from you, nearly two miles away on the left; for the whole country is full of roving bands of Frenchmen, and the ridges to the S.E. may conceal their movements towards the German rear, which, though not likely to be made in force, would be calculated to create uneasiness if their real nature were not known.

The movements are difficult in the snow, and the march of the left attack must take some time, so the German guns fire slowly to reply to those of the French, and to engage attention, keeping themselves ready to crush any counter attack along the La Loupe and Chartres roads, of which they have a perfect command. The French are passive, and two hours pass away with this insignificant duel of field guns.

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At 11 o'clock some fresh Lancers are seen coming from the La Loupe road; they bring the news of the approach of another German column, consisting of 3 Battalions, 4 Squadrons, and 6 guns. Soon the guns open in the midst of the enclosures on the far side of the La Loupe road, south of Coulonges, *i.e.*, due west of your position; they are firing on the French in the farms below La Fourche and round the shoulder of the hill. One Battalion of this new column deploys across the La Loupe road, another is in reserve behind it, while the third has been sent round by the position of the guns towards the French left. The Germans are attacking on a front of over 5000 yards, and the French in this enclosed country may be excused for estimating their numbers at 13,000, but 6500 is nearer the mark.

Soon the guns of the right attack move forward, a sure sign that all is going on well there; the French, however, on the La Loupe road are no longer passive but move quickly to the attack. The Germans deployed across the road begin to fire rapidly. There is a sharp engagement lasting some little time. Again the slow advance recommences. The French have failed.

At about 1 o'clock firing breaks out in the woods on the French right, the German left Battalion moving by Bouvereau having reached the enemy; and not long after the sound of heavy firing and cheers come round the end of the La Fourche ridge where le Verrier farm has been captured. Now the Germans advance along both the Chartres and La Loupe roads, and bring their reserve Battalions up to fill the central gap.

At 2 p.m., the German Infantry is so close all round La Fourche that their guns have to cease firing. Shortly afterwards the French guns are silent, three of them having been captured. The fight seems ended, but again breaks out, a gallant attempt being made to regain the French guns by a charge of 1½ Battalions along the main road. Again all is silent save a few musketry shots ever receding to the south-west. But just as darkness falls the growl of the mitrailleuse is again heard; it is the French making a last, and this time a successful, stand at La Cour au Loup, to cover the retreat.

To regain Condé station go by La Brulardière, les Bordes, and Rivray. To reach La Brulardière leave the ridge to the north, and gain a good cross-road; turn left (W.) along this, and cross the La Loupe road at La Brulardière, taking the Coulonges road as far as the second lane on the left at the head of the side-valley running down to that village. From this point bear to the left nearly due east along unmetalled lanes until the railway is reached at Rivray. Shortly after leaving the Coulonges road the position of the German guns of the right attack is crossed, and le Verrier is seen, a large farm lying on the western slope of the La Fourche ridge at the bottom of the steep part covered with heather, and protected from the fire of French guns by the slopes and woods in its vicinity. At Rivray, turn to the left (S.W.) along the good road running by the railway, and continue straight on to Condé village.

The length of the walk is under 12 miles.

(To be continued.)

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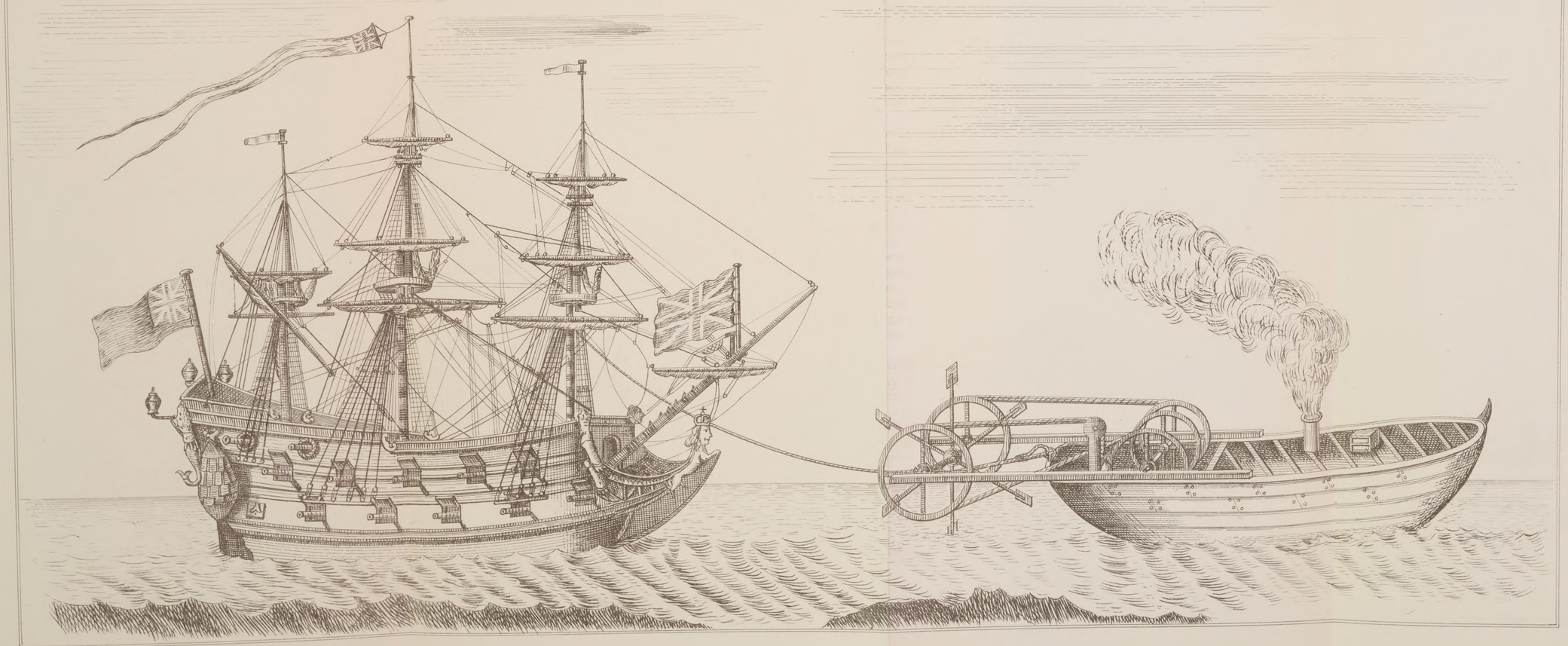
A New-Invented Machine for carrying Vessels or Ships out of, or into any Harbour, Port or River, against Wind and Tide, or in a Calm. For which His Majesty has Granted Letters Patent, for the Sole Benefit of the Author, for the space of Fourteen Years.

By Jonathan Hulls.

1737.



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THE MANUFACTURE OF STEEL, AND ITS APPLICATION TO MILITARY PURPOSES.

A Lecture delivered at the R. A. Institution on 6th March, 1884,

(MAJOR-GENERAL H. A. SMYTH, COMMANDING THE DISTRICT, IN THE CHAIR),

BY

CAPTAIN G. MACKINLAY, R.A.

THE Chairman introduced the subject by referring to the rapidly growing importance of steel for military uses, and to the peculiarities of manufacture by which its nature was determined.

The striking increase in the world's annual production of iron and steel during the last few years is shown by the fact (Fig. 1[1]) that the amounts produced have risen from some 10½ million tons in 1869 to about 21 millions in 1882—an enormous quantity, due to the vast development in the use of iron and steel for railways, machines, bridges, ships, buildings, &c. Apart, however, from the increase in the total quantities, we notice (Fig. 1) that cast-iron, wrought-iron and steel have not increased uniformly, but the last has far surpassed the others in the rate of its growth, having multiplied some 12 times in the 13 years under consideration.

Although steel has been made from remote ages, it was only about 25 years ago employed on a comparatively small scale for such articles as tools, knives, swords, springs, &c., and from the expenditure of time and fuel on its manufacture, it was necessarily an expensive article; but the inventions of Bessemer, Siemens, and others, have resulted in the production of a class of "mild" steel in large quantities, moderate in price, suitable for various purposes of construction, and surpassing wrought-iron in all, or almost all, of its good qualities.

It may be interesting to notice the proportion of iron and steel annually produced (in 1882 for example) in each country[2] (Fig. 2):

[1] *Vide* President's address, Iron and Steel Institute, 1883.

[2] *Vide* "Journal, Iron and Steel Institute," 1883.

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we are at once struck by the salient feature that Great Britain is far ahead of all others in *quantity*; in fact, excluding the United States, her production probably exceeds that of all the rest of the world put together. A great majority of modern improvements in iron and steel manufacture are due to English inventors, practically developed by English manufacturers. Abundant quantities of ores of iron, and good coal, as well as materials for fire bricks and fluxes are found in our island, while our splendid carrying trade gives facilities for plentiful supplies of the good ores of Spain, and the pig iron of Sweden for modern steel making, as well as for the export of manufactured iron and steel to foreign customers.

Second on the list comes the United States, where the demand to meet the wonderful development of the railway system, and other public works, has given an extraordinary impetus, especially to steel. Although the Americans have themselves undertaken manufacture in earnest, they receive annually more than a million tons of iron and steel from us, and they are not yet able to produce mild steel of that good and reliable quality which is required for ordnance, the reason perhaps being,

FIG. 1.

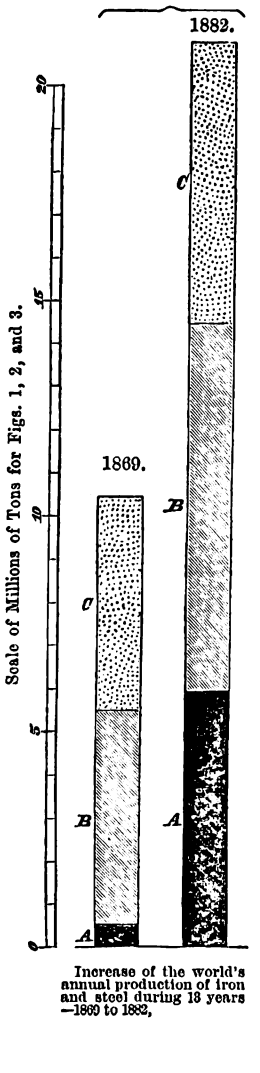


FIG. 2.

The production of iron and steel by the countries of the world in 1882.

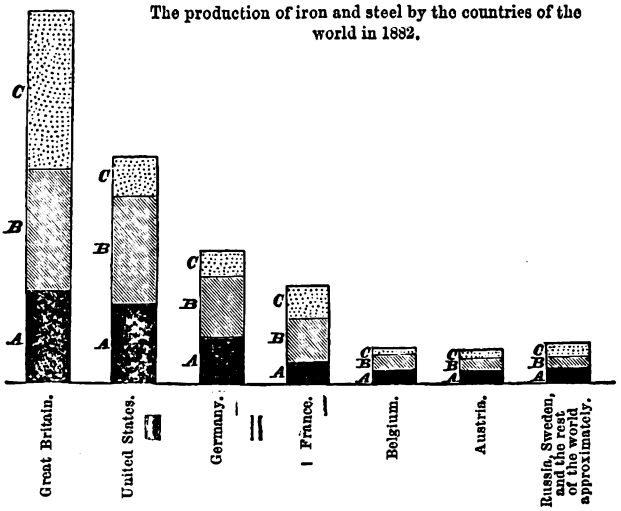
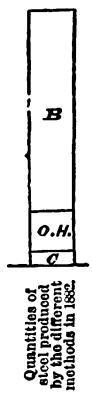


FIG. 3.



Figs. 1 and 2:—*A*, steel; *B*, wrought-iron; *C*, cast-iron. Fig. 3:—*B*, Bessemer; *C*, crucible; *O.H.*, open hearth.

that until now, there has been little or no demand for it. The United States have lately sent a Military Commission to make enquiries in Europe concerning the manufacture of steel.

Next on the list of producers comes Germany, which possesses the

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largest manufactory in the world—that of Krupp—remarkable for its excellent steel, which soon attained a wide reputation, as shown by the fact that in 1865, England ordered from this firm for her own use and that of her Colonies, no less than 11,396 tyres and 564 axles for railway purposes.[1] Krupp early applied his steel to the manufacture of ordnance, and he has supplied several nations with guns.

Fourth in magnitude, comes France, with her well-known Le Creusôt, Terre Noire, and other works. The first, with its massive plant and 100-ton hammer has produced steel armour plates of excellent quality; while the second has, after many difficulties, attained great success in steel castings, and in the manufacture of steel projectiles. Although the loss of Alsace has told heavily on the production of iron and steel by France, and though half her ores are imported, her progress is certainly very good.

Austria, though formerly celebrated for metallurgical manufactures, and possessing excellent ones, has been unable to keep pace with other countries in the production of iron and steel. The want of coal, and of easy communications, and perhaps the lack of organization and capital, have proved hindrances to development.

Belgium, on the other hand, has good supplies of coal, but having exhausted her own ores, has to import for the manufacture of steel; nevertheless, the thrifty Belgians have made good progress, especially considering the means at their disposal.

Russia possesses excellent ores in the mountains of Siberia and the Ural, but the want of good means of transport and of coal, prevents a large manufacture; but mild steel has been made since 1876, and the production is now considerable.

The best Swedish pig iron is of capital quality, as the ores from which it is produced are very pure, and the charcoal employed as the fuel in smelting being free from sulphur, does not contaminate the cast iron: but the want of coal, limits the supply.

Spain cannot be called a manufacturing country; but the Bilboa ore is now largely used in steel making, and it is exported in very great quantities.

Italy has hardly any iron or steel works; the Elba ore has long been famous, but is not so important as formerly.

The other nations of Europe produce but little iron and steel, and they are chiefly supplied from those already named. In the other countries of the world considerable progress has been made, in some of the Colonies, and a little in India.

Definition of Steel, and its Properties.

Steel is by no means easy to define, since it is a complex body, and as all persons are not exactly agreed as to the difference between it and iron, lawsuits have consequently arisen; but the definition of Holley, quoted in the Royal Gun Factory Treatise, that it is "an alloy of iron, cast, while in a fluid state, into a malleable ingot," has, at any rate, the

[1] *Vide* "Steel," by J. S. Jeans.

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advantage of simplicity, if not of perfect exactness.[1] This definition serves to distinguish it from cast-iron on the one hand, and from wrought-iron on the other: as cast-iron is not malleable, but crumbles to pieces if heated and struck by the hammer,[2] and wrought-iron, though malleable, is produced, not as a fluid, but as a pasty mass, the temperature of the ordinary furnace being insufficient to melt it.

Wrought-iron is more fibrous than mild steel, and it contains, from the method of its manufacture,[3] an average of 3 p.c. by weight, or 7½ p.c. by volume of slag, dispersed through its mass in fine filaments, which detracts from its strength: on the other hand, the process of fusion in the manufacture of mild steel gets rid of all traces of slag[4]; and this is a great advantage. Old definitions of steel stated that the proportion of carbon in it was more than in wrought-iron, but less than in cast-iron: but this hardly holds good at the present time, when some mild steel has no more carbon than some wrought-iron. Sir W. Armstrong states that "steel is iron produced by a process of fusion instead of by one of adhesion, and in that sense it is independent of any particular degree of carbonization. Using the term in this sense, steel has the advantage over iron in being free from defects in welding. It generally contains more carbon than wrought-iron, which renders it stronger. It is also tougher under some tests, but more prone to fracture under others . . . . . The manufacture of steel continues to improve, while that of iron is stationary, and the time is probably near when the manufacture of iron, as now practised, will entirely merge into that of steel, as produced by the process of fusion."[5]

Taking Holley's definition, carbon is the essential substance which alloys with iron to form steel; it increases the hardness, elasticity and tenacity, though it decreases the elongation before fracture: it also gives rise to the important property of tempering by rapid cooling, by which these advantages can be increased, though with a further loss of power to elongate, as shown in Whitworth's diagram of test pieces (Fig. 4). Annealing, or softening by slow cooling, may be called the reverse of tempering. The presence of carbon, however, greatly adds to the difficulty of forging, which must be done at a lower temperature as the proportion of carbon increases; if too hot, the mass will crumble to pieces under the hammer, or if this does not actually take place the result will be to give brittleness instead of strength in the operation of forging—producing what is technically called "burnt steel:" in explanation of this remarkable fact it can only be stated that some physical and (possibly) chemical change takes place in steel at a certain temperature depending on the propor-

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[1] "Homogeneous iron" is a name sometimes used instead of mild steel.

[2] This plan is actually employed in the Royal Gun Factory, in breaking up parts of old cast-iron guns into pieces of convenient size for re-manufacture.

[3] *Vide* Lecture by Sir W. Siemens, "Proceedings," Royal United Service Institution, 1879.

[4] The absence of slag probably accounts for the fact that steel resounds much better than wrought-iron when struck. Steel bells have come into use on a considerable scale.

[5] *Vide* Presidential address, Society of Civil Engineers, 10 January, 1882.

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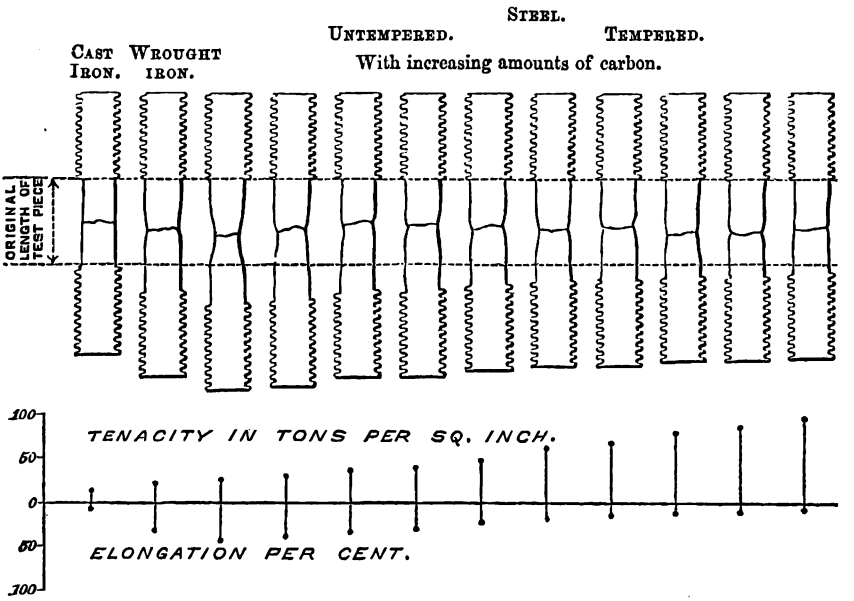
tion of carbon present, which causes it to assume a coarsely crystalline structure, greatly decreasing its strength and reliability: this generally renders the forging of steel much more tedious than that of wrought-iron, which can often be heated to a white heat when it becomes soft, and it can be quickly hammered into the required shape. At the beginning

FIG. 4.

WHITWORTH'S TEST PIECES.

Showing how increase of tenacity is attended by loss of elongation before fracture.



N.B.—The thick ends of the test pieces have a rounded screw thread on them by which they are grasped in the testing machine.

of steel making, the necessity for care about the temperature for forging was not fully recognised, and "burnt steel" was often produced, accounting probably for many of the mysterious fractures which happened, and which gave reason for so much distrust. At Terre Noire especially, the men who had been accustomed to deal with wrought-iron could not understand for a long time that steel must be treated differently, and experience was only gained at the cost of a good many failures. On one occasion, the ordinary workmen were turned away, and carpenters who had to learn the work, but who would do what they were told, were engaged instead.

Mild steel can be welded like wrought-iron, but the operation becomes more and more difficult as the carbon increases: the 13-pr. steel axletree is consequently made in one piece without any weld; but wrought-iron axletrees are most conveniently made in two pieces, which are afterwards welded together.

It is more difficult to cast mild steel than cast-iron, because a more uniform result is required, and since the temperature of fusion is so

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much higher (from the smaller proportion of carbon) much greater contraction takes place on cooling, giving rise to a variety of intense molecular strains, which are sometimes sufficient to tear the metal apart in the mould, and often cause surface cracks, telling of a state of strain which must be allowed for and counteracted, as far as possible, by suitable methods of cooling and re-heating. Krupp takes the greatest care on this point, making the cooling of his ingots very slow indeed, keeping them warm with hot ashes sometimes for weeks; and they are said to be remarkably free from cracks or flaws. Annealing for several days is often resorted to in the case of steel castings.

As small differences in the proportion of carbon make very great differences in the elasticity, tenacity, hardness, elongation, &c., it is most important to use every effort to control the quantity admitted into steel in manufacture, and it is one of the greatest aims in making steel for ordnance to obtain, as nearly as possible, the desired proportion of carbon; for this purpose it ranges from about 0·25 to 0·5. For the hard steel face of compound armour plates it may be as high as 0·8 p.c.

In all modern steel there is a considerable proportion of manganese, this is supposed to act in the same way as carbon in hardening, but its effect is not so marked. It is always added to melted steel in manufacture, in order (it is supposed) to take away ferrous oxide, which forms at a high temperature, and also, to a certain extent, it may take away other impurities which would impart red shortness or brittleness at the forging temperature; as manganese has an extraordinary affinity for oxygen, it is prepared for use as an alloy with carbon and iron termed spiegel eisen or ferro-manganese, according as the proportion of iron or manganese predominates; both of these alloys are now important articles of commerce. When the manganese mixture is put into the liquid steel, some of it immediately attacks the ferrous oxide, deprives it of its oxygen, and becoming itself oxidized, runs harmlessly into the slag, leaving a certain small quantity of metallic manganese to alloy with the steel; this is the last operation before pouring out in the Bessemer and "open hearth" processes, so that no time may be given for the formation of any more ferrous oxide. Mild steel should not in any case have more than about 0·8 p.c. of manganese, or it will be brittle, but it is generally best to have less than this quantity. Messrs. Hadfield & Co., however, have lately produced a steel, having as much as 12 p.c. of manganese, which is said to possess good qualities. It is very hard but not brittle, and it is said to be unaffected if heated and plunged in water.

Silicon has the property of rendering cast-steel ingots sound and free from blow holes: small quantities of pig iron, rich in silicon, are often added for this purpose: it is supposed to de-oxide the carbonic acid gas which forms the bubbles, and thus silica is produced which enters the slag—not more than about 0·2 p.c. of silicon should be present, and much less if the steel is to be of very mild quality (or brittleness will be produced).

Sulphur and phosphorus (especially the latter) are the enemies of the steel maker, for if present beyond a very small amount (say 0·04 and 0·06 respectively) they produce brittleness: as a very large propor-

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tion of the ore-deposits in the world contain too much phosphorus to allow them to be used in the manufacture of steel, as it is generally carried on, it has long been a great problem to invent some process by which it could be eliminated, and it appears that this has at last been practically accomplished by the basic process, invented by Messrs. Thomas and Gilchrist, in which freshly calcined magnesian limestone (dolomite) absorbs the phosphorus almost entirely when the metal is melted, and by this process good steel has been produced from highly phosphoric ores. Although this plan was invented by Englishmen, it has been more widely adopted in some parts of the Continent (where phosphoric ores abound) than in England, where good ores are generally procurable from abroad if not close at hand; the results have been so good that it seems as if a new departure has occurred in the progress of steel making; already some $\frac{3}{4}$ million tons of steel are manufactured annually in Europe from phosphoric pig: and at the late Amsterdam Exhibition the highest award of honour was given to the inventors. It must, however, be stated that ores rich in silicon present some difficulty with this process, as the furnace lining is much corroded, and care must be taken to use freshly calcined limestone, as it soon absorbs moisture from the atmosphere.

The power to resist abrasion and rubbing, possessed by mild steel, is greater than that of wrought-iron; this is apparently due, not only to greater hardness imparted by more carbon, but it also results from the greater uniformity of its structure: wrought-iron, on the other hand, flakes off, from the presence of filaments of slag. The advantage of mild steel over wrought-iron in this respect has been shown in a marked manner by the superior endurance of steel rails: as for instance, when the London and North Western Railway Company some years ago made a careful experiment at Chalk Farm Station, at a spot where the traffic was specially heavy, steel rails lasted 23 times as long as wrought-iron ones on the other side of the same line. Steel has consequently been widely adopted for rails, though it cannot be said that all now manufactured are of such good quality as those made for that experiment. This same property was long ago recognized in gun making, when the bores of ordnance, which have to resist the abrasion of studs, &c., and the erosive action of fired gunpowder, were made of steel.

The process of drawing into wire increases the elasticity, tenacity, and elongation of steel to a degree unattainable in any other way. Advantage has of late years been taken of this fact in the manufacture of ordnance, as this method also allows of the initial tensions being very accurately adjusted, and no extensive flaws can remain undetected.

Many other physical and chemical properties of steel might be considered, but those just mentioned are probably the most important for our purposes.

Manufacture.

Excluding the older processes for the manufacture of hard tool steels, we find that mild steel for constructional purposes is produced

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by the three following methods, (in the proportions denoted in Fig. 3, p. 588) viz.:—

1. Crucible. 2. Open hearth. 3. Bessemer.

In each of these plans a very high temperature must be obtained in order to melt the steel, which must not be in contact with the solid fuel, because if it were so, the proportion of carbon in the steel would be too large; and means are always taken to render the product as uniform as possible.

(1) The crucible plan (Fig. 5) is the oldest, but it is now the least employed: it has long been known that wrought-iron enclosed in a crucible with carbonaceous matter is capable of combining with the carbon, and melting, to form steel, at a temperature insufficient to melt wrought-iron alone. At the present time, carefully weighed proportions of wrought-iron, with sometimes a little steel, or even good cast-iron of known composition, powdered charcoal, and spiegel eisen are put into a crucible capable of holding some 60 to 100 lbs. weight, this being about the limit which its strength will enable it to bear without risk of cracking. A number of such crucibles are placed in a furnace specially constructed for their reception; a very high temperature is obtained, and after some $2\frac{1}{2}$ to 3 hours, according to the degree of carbonization required, the contents are melted, the carbon has alloyed with the iron to form steel, and the manganese in the spiegel eisen has reduced any ferrous oxide which may be present. A liquid slag formed at the top, and a fire-clay cover prevent oxidation, which might otherwise occur at the high temperature attained; the contents of several crucibles are then poured into the same ingot mould as rapidly as possible. Krupp has greatly developed this method, and he has poured from as many as 1800 crucibles into one mould; great care and arrangement in the large numbers of men employed being necessary.

The advantages claimed for this plan are that the flame is not in contact with the steel, and therefore cannot contaminate it; and uniformity of quality is gained if the temperature and time of heating are the same, otherwise the re-actions may differ in different crucibles if the heat varies in duration and intensity. The disadvantages are, the expense and the great care and arrangement necessary for very large ingots, when great numbers of men must be carefully trained to work together; the length of time taken in casting is also a drawback: but the product is often excellent, if all necessary conditions are observed, and it has been largely employed for gun tubes, as for instance, in our Service, where Firth's crucible steel is much used.

(2) The "open hearth" plan is perhaps the most recent method of steel making, and it owes its success to the inventions of Siemens, Price, and others, who have constructed furnaces of the reverberating type, capable of producing very high temperatures. The so-called hearth is somewhat spoon-shaped, sloping down to one point, (*B, B*, Fig. 6, where the tapping hole is situated) and the bed is covered

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with partly fuzed sand; good cast-iron is first thrust in, and the flame beating down, or reverberating from the very low roof, soon melts it, as it is readily fusible from the large quantity of carbon which it contains, and thus the so-called "bath" is formed. Sometimes only one kind of pig iron is used, but generally it is more economical to make a mixture; for instance, a very pure Swedish pig may be combined with a cheaper iron from English hæmatite ore, which has a good deal of sulphur, but not enough to make an injurious amount in the mixture, and sometimes steel is mixed at first with the cast-iron. When the bath is sufficiently fluid, steel scrap, crop ends of rails or wrought-iron are thrown in, after being warmed by the waste heat: the object being to obtain a mixture having less and less carbon; when these have been well melted down, a further reduction of carbon is effected by the addition of known quantities of good Spanish hæmatite ore—an oxide of iron. When this is added, a violent ebullition ensues, due to the combination of the carbon in the melted charge with the oxygen in the hæmatite, and the consequent production of carbonic oxide gas; this is technically called "boiling." The whole operation *might* be done by the use of pig iron and ore without any wrought-iron or steel: this was a good deal practised at one time, but it was found to be very expensive, as more fuel was required, and the wear and tear of the furnace lining was considerable, from the corrosive action of the large quantities of slag produced. During the latter part of the process, the steel maker is constantly testing the composition of the molten mass, by inserting a long iron rod with a spoon at the end of it, and taking out a little of the steel: this is judiciously cooled, hammered on an anvil, bent over and broken, and the fracture and general appearance are compared with other samples previously obtained which have given good results, and which have been chemically analysed. If it is judged that the carbon is not low enough, more ore must be added if no "boil" is going on; but if, on the other hand, it is too low already, some good pig iron must be put in; and on leaving off the operation, the steel should be as quiet and free from bubbles as possible, to avoid blow holes in the casting.

Great practical skill is required on the part of the steel maker; his tests must be taken rapidly, and a judgment must soon be made from the scanty and apparently rough data furnished by the comparison of the test pieces with the standards; but nevertheless, the same results may be repeatedly attained by the same operator within comparatively narrow limits.

Just before the pouring out, comes the addition of the proper quantity of spiegel eisen or ferro-manganese; both of these necessarily contain carbon, and consequently the melted mass should previously be decarbonized below what is required in the finished material. The manganese is previously heated, carefully scattered over and stirred up in the steel, so as to ensure uniformity of composition: a rapid test is taken, the tapping hole at the bottom is knocked through by means of hammers and a long rod, and the liquid steel flows out along a gutter into a large iron ladle lined with fire-clay, and previously heated: if not heated, or if the temperature of the liquid steel is too

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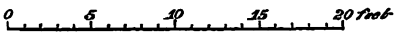
low, a good deal of waste occurs from the formation of a considerable "skull," or metallic lining, caused by the solidifying of the outer part of the steel in the ladle. When all the steel has been poured out, the ladle is carried by a powerful crane to the ingot mould it is desired to

CRUCIBLE PROCESS.

FIG. 5.

Approximate Scale for Figs. 5 to 9.

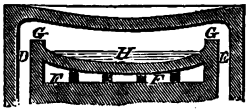


OPEN-HEARTH PROCESS.

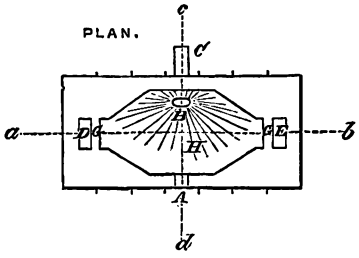
FIG. 6.

Elevation.

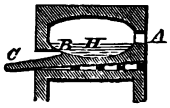
Sectional Elevation on *a b*.



PLAN.



Sectional Elevation on *c d*.



A Charging door.
B Tapping hole, which is intended to be at lowest part of hearth in the plan and sectional elevation.
C Spout.
D E To fuel and to chimney (generally reversible).
F Air spaces underneath to keep the outer parts cool.
G Fire bridges.
H Hearth.

BESSEMER PROCESS.

FIG. 7. Charging.

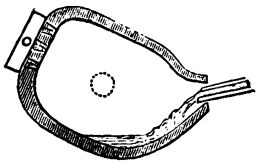


FIG. 8. Blowing.

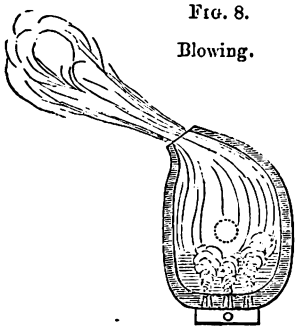
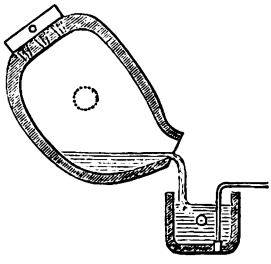


FIG. 9. Pouring out into the ladle.



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fill, and a plug is raised at the bottom, worked by a rod passing through rings of fire-clay in the liquid mass: the steel then runs out of the bottom of the ladle and fills the ingot mould; the slag being lighter remains at the top and is not mixed up with the steel, unless indeed any difficulty occurs with the bottom plug, when the steel must be poured from the top of the ladle, as water is from a jug; in this case, small quantities of slag may become entangled in the steel, and the ingot will probably be spoilt.

Sometimes the metal is run direct into the ingot mould without the use of a ladle, but this is not generally considered a convenient plan. The whole operation lasts from 7 to 11 hours, according to the size of the furnace and the weight of charge; the largest furnaces yet made will melt about 20 tons at a time; the furnace bottom needs repair after each charge. The advantages of this process are that it is cheaper than the last, the composition of the steel can be very carefully controlled, but it requires very great attention and skill on the part of one or two responsible persons. It is very largely employed in making steel for ordnance, carriages, and other military constructions where uniformity and high qualities are more desirable than economy.

(3) By far the largest proportion of mild steel (about 80 p.c., *vide* Fig. 3, p. 588) is manufactured by the Bessemer process, but it cannot be applied to military purposes to anything like that degree. The rapidity and economy of this plan are considerable, and the whole operation is startling and impressive. A large egg-shaped iron vessel called a "converter" (Figs. 7, 8, and 9), can revolve on trunnions, one of which is provided with teeth which gear with rack work, by means of which it can be turned up or down. The other trunnion is hollow, and through it comes a pipe communicating with a great number of small holes or "tuyères" fitted with fire-bricks situated in the bottom of the vessel; a blast of air can thus be sent from an engine through the tuyères. The top of the converter is provided with a short chimney, and the interior is lined with a very refractory material called ganister. The operation is as follows:—the converter being heated, it is turned down (Fig. 7), and melted cast-iron is poured in by a gutter, either from a re-heating furnace, or in some cases, as first practised at Terre Noire, direct from the blast furnace, where it is reduced from the ore; when a sufficient charge has been poured in—only about $\frac{1}{8}$th of the total capacity, so that the iron may not rise to the tuyères on pouring in—the blast is turned on, and when it is fully on, the converter is turned up (Fig. 8); the liquid iron cannot run down the small tuyère holes through which the blast comes, but on the contrary, the pressure is sufficient to cause a continuous stream of bubbles of air to rise up through the molten mass, thus oxidizing the carbon in it with the formation of carbonic oxide gas, which burns with a strong flame some 20 feet in length at the top of the chimney.

The temperature of the iron is considerably raised by the combustion of the carbon in it, and, although it becomes de-carbonized and consequently more infusible, it still remains liquid; after some 20 minutes the flame becomes much shorter and alters in character, signifying that the carbon

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is becoming very low, and that the operation is nearly completed; it is essential that the exact time of leaving off should be chosen, as if the "blow" is stopped too soon, sufficient carbon is not extracted; if, on the other hand, it is continued too long, the iron becomes oxidized, when not only is some of it wasted, but the quality of the rest is spoilt, for the iron itself burns, and excess of oxide is formed. The appearance of certain lines in the spectroscopic appearance of the flame is used to find the proper time for leaving off, but it is often determined by eye alone. Before pouring out, however, comes the addition of manganese, which is absolutely necessary in this plan; as from the method of manufacture a good deal of ferrous oxide must necessarily be formed; the "blow" is continued for rather less than a minute, after which the steel is poured out into the ladle (Fig. 9), when it is sometimes stirred by means of an "agitator" to distribute the manganese and produce uniformity. The ingot casting is the same as in the "open hearth" system.

The rapidity of this plan enables an enormous output to be made with a moderate plant, as each "blow" lasts less than half-an-hour to produce 6 to 12 tons of steel, but this very rapidity prevents the careful control over the results which can be exercised in the last method: in a large firm this can be allowed for by sorting the ingots produced, and applying each to the purpose for which it is most suited; but it is most difficult to know what will be the exact proportions of carbon and the other qualities of any particular "blow." It does not appear at present to be well suited for the manufacture of ordnance; and the following extract from the "Proceedings of the American Society of Civil Engineers" about the Monongehela bridge, Pittsburg, seems to represent the facts concerning the employment of this steel for work of the higher qualities.—"The difficulty seemed to consist in controlling the uniformity of the steel within close limits for quality and strength with the Bessemer process. After a while, the attempt was given up, and the "open hearth" was substituted—no trouble was then experienced in getting a uniform grade of steel of prescribed quality." Some 42,000 tons of "open hearth" steel will be used in the construction of the Forth Bridge. Bessemer steel is very much used for rails, as the limits allowable are somewhat wide, and also for a great variety of other purposes, including compound armour.

Forging.

When steel is to be forged, it is cast into an ingot mould of a very simple form, efforts being made, by the use of silicon, either in the pig or in a special mixture, or by fluid pressure as used by Whitworth, to get rid of blow holes: the ingot is taken out, re-heated, carefully inspected, cracks cut out, and it is then either hammered, rolled, or pressed to the required shape, great care being taken about the temperature. In order that the blows may be well transmitted through the mass, it appears that very heavy hammers are now generally preferred, probably because mild steel is not in as soft a condition as wrought-iron when forged. As large masses of steel are now worked, it is probable that

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the numbers of already existing very heavy hammers may be increased: on this point it appears that more progress has been made in some of the leading factories abroad than in England; and this seems an important matter for our manufacturers to consider, with reference to the large masses required for ordnance. Larger ingots have been produced and forged in France and in Germany than in England.

Increase of tenacity can be obtained by the important operation of tempering, but this is at the expense of elongation before fracture. The temper obtained varies with the amount of carbon in the steel, the temperature and the nature of the cooling material—rape oil being generally considered the best for large masses, as it has a less conducting power than water, and cools the metal more slowly. Krupp is said to temper his steel at a uniform heat: while our plan for ordnance is to temper a test piece at 1450° F., and if this does not give good results, the temperature is varied within certain limits, and then the whole mass treated in the same way, as nearly as possible, as the test piece which gave the best results. Tempering lowers the specific gravity slightly, consequently warping and surface cracks are often produced by this operation, when large masses are operated upon. The Schneider[1] steel plate at the Spezzia experiment in 1882, was tempered in the face to gain hardness, and it consequently warped so much that it had to be planed off at the corners to make it fit the frame it was placed in. Gun tubes often develope surface cracks after tempering, but sufficient thickness of metal is allowed so that they may afterwards be cut out in the lathe.

Steel Castings.

With steel castings, every effort is made to get rid of blow holes; this generally involves (for all good work) a very considerable dead-head, which adds to the expense, and has to be cut off. Annealing for several days is resorted to by some, while others are content with slow cooling in hot ashes; tempering is sometimes used for special purposes, such as the head of an armour-piercing projectile, though it cannot be said that cast-steel projectiles are as yet very successful for armour-piercing purposes.

In designing the shape of a casting, sharp corners and great differences of thickness must be avoided on account of the difficulties of preventing unequal strains tending to produce rupture in contraction on cooling down.

Tests.

A great variety of tests are applied to steel in different places, according to the purpose for which it is required; latterly there has been a growing tendency towards uniformity;[2] the workman's rough tests of bending, breaking, and observing the fracture have been systematized in various pulling machines, actuated by a dead weight or by levers, or by hydraulic pressure, by all of which the limits of

[1] *Vide* Lecture by Captain Orde Browne,—"Proceedings," Royal Artillery Institution, 1883.

[2] *Vide* paper by C. E. Hackney,—"Journal, Society of Civil Engineers," 1884.

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elasticity and tenacity are indicated; bending and torsional tests are also often applied, and in other cases dynamical trials are made, as by dropping heavy weights on to rails, or by exploding guncotton, as is sometimes done with boiler plates, which are made of very mild steel, having but little carbon.

For ordnance, the tension and bending tests are generally sufficient; the elasticity, tenacity, and elongation are carefully recorded, and the area of the fracture and its general appearance are also noticed, both before and after tempering. In our manufacture, the behaviour of the tempered test piece serves as a guide for the treatment of the mass from which it came; but it appears now to be generally acknowledged, that the same heat will cause a different temper in a small test piece, and in the large mass, as the latter will cool so much more slowly, and will not, therefore, be so much affected as the smaller piece. It seems a sound method to proceed (as it is believed the French do) to cut a piece off the tempered mass and then test it, and the result will be a more certain knowledge of the tenacity, &c., really attained—more particularly as with all the care at present used, it is not possible to be quite sure that the large mass is brought to the same heat as the test piece was. The elongation on fracture has of late attracted attention, as it is a well recognised fact that a short test piece will elongate much more p.c. of its length than a longer one of the same material; this is explained by the circumstance that as the elongation is only considerable just immediately at the point where rupture takes place, the

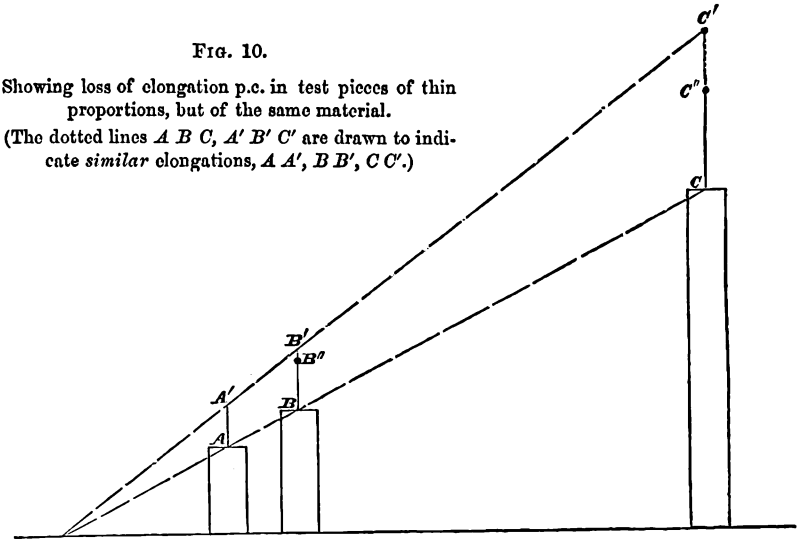

FIG. 10.

Showing loss of elongation p.c. in test pieces of thin proportions, but of the same material.

(The dotted lines *A B C*, *A' B' C'* are drawn to indicate *similar* elongations, *A A'*, *B B'*, *C C'*.)

total elongation of the long piece is not actually much more than that of the short piece, and it is consequently less in proportion to its length (*vide* Fig. 10, where a test piece of Whitworth's dimensions is supposed to elongate an amount A A'; if the same material is made according to Royal Arsenal pattern, it will only elongate B B'', instead

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of B B′, which would be in the same proportion as the last, while if the test pieces are still longer, the elongation C C″ is even less p.c.)

It is usual to say that the elongation is so much in a test piece of so many inches, but this is not really correct, as a thick piece will elongate more than a thin one: it is now proposed that all test pieces shall be of the same proportion of length to thickness.

It is important that the tests imposed should be reasonable and possible, but this apparently has not always been the case, as, for instance, when iron was first employed in the construction of ships, the test imposed by Lloyd's, and afterwards by the Admiralty, was the single one of good tenacity, irrespective of elongation, before fracture; the consequence was that much inferior brittle iron[1] was built into many a vessel, accounting, doubtless, for numbers of casualties. On the other hand, to show the advantage of good elongation before fracture, many instances have occurred of steel vessels grounding in rocky places, when the bottom plates have been bent and crumpled, but not fractured, as they doubtless would have been if they had been brittle, although with a high tenacity. Going to the other extreme, the demands for tenacity *and* elongation, within certain limits of temperature for tempering, have been so high in some specifications that it has not been found possible to come up to the standard when large masses have been supplied; the steel has in some cases been rejected wholesale, whilst at other times, it has been passed, when the tests being set aside became useless.

Not only are mechanical tests employed, but the chemical composition of steel is found by quantitative analysis in a most systematic manner; and each large factory has a regular laboratory, with one or more analysts, a class of men created by the requirements of the modern steel trade, in which sound scientific training in those concerned is a *sine quâ non* for successful manufacture.

Steel for Military Purposes.

Little more than a year ago a most important decision was made that our ordnance, of all calibres, were in future to be constructed entirely of steel; and wrought-iron coils were abandoned, as there was no longer a doubt that steel is much superior to wrought-iron for this purpose, from its greater strength; and this has been especially noticed with guns firing the modern large charges of slow-burning powder. The steel for ordnance should be of such quality[2] as to possess a considerable elastic limit, so that permanent deformation or enlargement of the bore may not take place to any appreciable extent; and a most important requisite is uniformity and trustworthiness: its *uncertainty* was always urged as a reason for its non-adoption in the service as long as wrought-

[1] *Vide* Jean's "Steel."

[2] Gun steel, for our Service, must in the untempered state have its elastic limit between 11 and 15 tons; tenacity between 27 and 35 tons on the square inch, with an elongation of not less than 15 p.c.; in the tempered state the elasticity must range between 25 and 33 tons on the square inch, and the tenacity from 38 to 48 tons, with an elongation of not less than 10 p.c. in the test piece of standard proportions. A certain amount of discretion is allowed in passing steel forgings not within the above limits.

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iron was used in manufacture; but it appears that reliability and uniformity are now being attained, though only by most unceasing and intelligent care in all processes of manufacture; especially is this recognised to be the case when very large masses are forged, as the difficulties in obtaining uniformity in the mass become greatly increased. The percentage of carbon is about 0·4 to 0·45 p.c. with crucible steel when the manganese is low; but with the "open hearth" steel the percentage is a good deal less (0·28 to 0·31) when more manganese is present.

The parts of steel ordnance are made as follows from the ingot:— The tube is drawn out under the hammer, and a core cut out of it or trepanned, thus saving the material cut to pieces in the old process of boring. The hoops are also made from an ingot which is trepanned, the ends cut off and re-melted, and the rest cut into thick rings in a lathe; these are afterwards heated and increased in diameter by hammering on a mandril placed through them, in the same way as the weldless tyres of railway wheels.

Trunnion hoops are also forged from ingots, and the parts of guns are shrunk together after the component parts have been carefully turned and bored to the proper dimensions. Small-arm rifles have long been made of steel.

Rocket cases, propeller shafts, air chambers and receivers for torpedoes, and some shrapnel shells are made of mild steel; and many experiments have been made with intensely strong steel shells, as, for instance, when a few years ago an important competition of 9-inch armour-piercing projectiles was carried out at Shoeburyness, when Whitworth's forged steel shells showed wonderful properties; and only last year a long 9-inch shell of his manufacture has succeeded in perforating, unbroken, 18 ins. of wrought-iron. But although we have not made very much progress of late in the manufacture of projectiles suited for the attack of steel or steel-faced armour, the attention of Continental Powers has been a good deal drawn to this subject. Doubtless, if sufficient inducement were held out, our manufacturers could produce what is wanted; but at present it is found that the very high velocities employed, and the "hard" armour, causes strains which our best heavy armour-piercing shells cannot satisfactorily overcome. Those of hard steel break up, and those of softer quality bend out of shape, at the same time, however, inflicting very severe damage on the plate; the difficulties of making armour-piercing shells increases very greatly with the calibre.

The superior strength of steel enables common shells to be made with thinner walls, and consequently with greater capacity for bursting charges than when cast-iron is employed. Krupp has made some shells of very large capacity; and we have made considerable experiments in this direction at Dungeness last year when firing at earthworks. Tubular steel appears to lend itself readily to this purpose, as has been done by Mr. Delmard, who ingeniously draws the metal to a point to form the head in some shells, and again bends in the lower parts of the sides of others to close up the bases; but generally the bases

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are screwed in, or welded to shells formed from tubes. Mr. Delmard has also made shells for small natures by stamping them from a flat disc of steel and drawing up the sides.

Tubular steel of the so-called "weldless" type is employed for lightness and strength in the construction of the new field axletrees, the whole of which is made of thick steel tubing, the arms as well as the body being hollow. The increased strains which the large charges of modern guns impose on gun carriages have necessitated the employment of steel in their construction, in order to obtain the necessary strength; and steel plates and axles are now freely used, as in the 13-pr., which has gone through the Egyptian campaign. For heavier gun carriages steel castings are much used for the more complicated portions, which cannot easily be produced by forging; but wrought-iron is still preferred for some parts, as for instance, for the trail eye of a field gun carriage, which is subject to constant jars. Steel racers have long been introduced for use with some of the heavier garrison guns, as they well resist the blow caused by the jump of the platform on firing, which indented the older and softer wrought-iron racers, and rendered subsequent traversing a difficult operation.

Armour.

The French Le Creusôt steel plate has been made from a large pile hammered down under the 100-ton hammer; and our compound armour is constructed on two plans by the only two firms who at present manufacture it in England.

The Atlas Works (Sir J. Brown & Co.) make it on Ellis' patent (Fig. 11): a good thickness of wrought-iron and a thin steel face plate are kept at a few inches distance from each other, with wedge plates round three sides, and small steel studs at several points keep them from coming too close to each other in the furnace: the whole mass is then strongly heated with the plates horizontal; when hot enough it is taken out and lifted by a crane, swung vertical, placed in a pit, and melted steel is poured from a large ladle into a trough which distributes little streams into the cavity between the two plates, and joins them together: in a short time, the whole plate is taken up and put back again into the furnace; when re-heated, it is taken out, and the whole is passed through the large rolling mill.

In Wilson's plan, adopted by Cammell & Co., a large wrought-iron plate built up of many thicknesses is passed through the rolls, and is then pushed horizontally into a huge iron chamber which can revolve on trunnions: when the plate is secured, the whole is turned up and becomes vertical, and liquid steel is poured in from a ladle and trough, between one side of the wrought-iron and the side of the box, precautions being taken to prevent it from flowing elsewhere. In this plan the steel was formerly poured on to a wrought-iron plate provided with a rim and placed horizontally; but this was given up, as the scum, &c., tended to remain on the face of the plate. The whole is afterwards rolled.

The steel constitutes about ⅓rd of the weight in both systems, its

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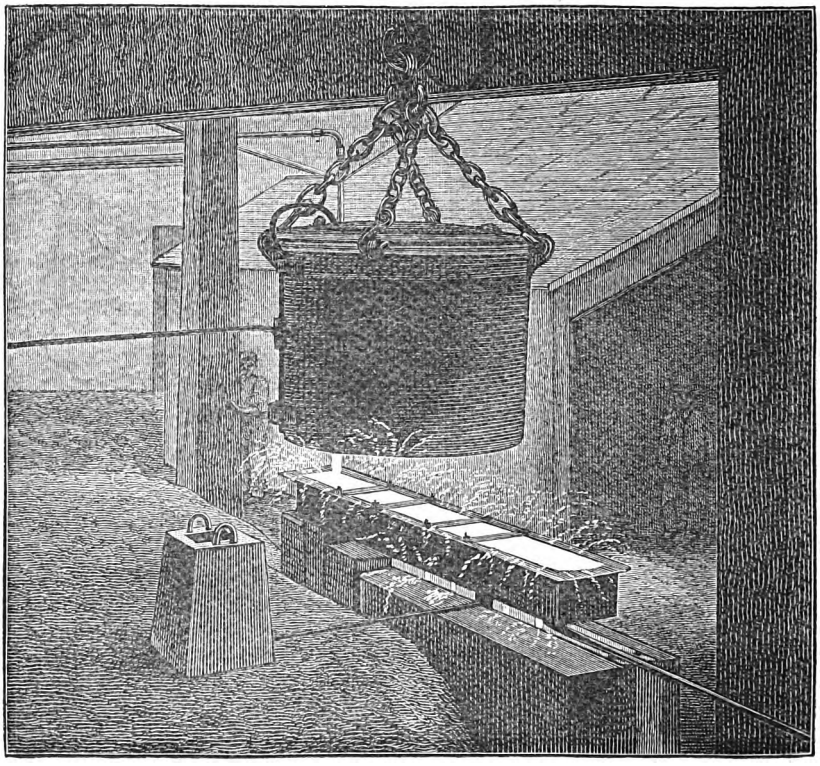
object being to break up the projectile on impact; it consequently has a considerable amount of carbon in order to give it the necessary hardness, while the wrought-iron at the back of the plate is intended to hold the plate together, and to prevent the formation of cracks and splits as far as possible. This class of armour has achieved

FIG. 11.



MANUFACTURE OF COMPOUND ARMOUR.

(SIR J. BROWN & CO.—ELLIS' PATENT),

From a Photograph.

POURING IN MELTED STEEL BETWEEN THE WROUGHT-IRON AND THE STEEL-FACE PLATE.

good results; the experiments at St. Petersburg and at Spezzia in 1882 and 1883, as well as some of our own at Shoeburyness, having been very favorable. Ellis' plan has the advantage of a very good front surface, but there are two joins in it, as the melted steel has to attach itself to the wrought-iron and to the steel-face plate, which sometimes flakes off near the point of impact when struck by a projectile. A Wilson compound plate has only one join, as the melted steel has only to attach itself to the wrought-iron, but the front surface is perhaps not quite so good as in Ellis' plan. Practically, the results attained by each are generally considered to be about the same as far as present experience has gone.

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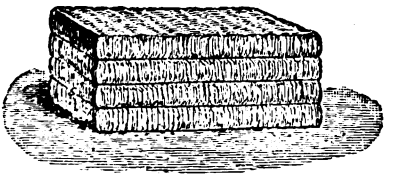
Thin steel plates for torpedo boats are far superior to those of wrought-iron, as their resisting power is much greater.

In the Royal Engineer Service, steel enters into many constructions, while in the Royal Navy, it is used on a very considerable scale for boilers and for the plates and frames of ships.

FIG. 12.



TRUSS OF HAY BOUND WITH BESSEMER STEEL WIRE.
Dimensions about 31″ × 19″ × 15″; average weight 87 lbs.

A variety of other uses for steel have been found in the services, as for instance, with compressed hay, which is reduced to a small bulk and then bound with strong Bessemer steel wire (Fig. 12); by this means large quantities can be stored on board ship, or elsewhere, in a smaller compass than formerly.

The Chairman then invited discussion.

CAPTAIN ORDE BROWNE asked if the fracture of steel ever showed a fibrous character, and if so, did the operation of forging cause the fibre to run round the gun hoops in an advantageous manner: he also asked Mr. Whinfield, who was present, if he could state whether many forged steel shells, similar to the 9-inch, which had perforated 18 inches of wrought-iron armour, had been supplied to Foreign Powers. With regard to armour-piercing projectiles, he urged that more progress should be made, and that experience should be gained in the attack of solid steel, which is employed in some of the most important foreign ships, and chilled cast-iron which is used in continental coast forts. At the present time we try to kill two birds with one stone, but unfortunately one bird is the wrong one; we try our own shells against our own targets, they never will be so used on Service.

MR. WHINFIELD (representative of Sir J. Whitworth & Co.) replied that no appearance of fibre is developed in Whitworth's fluid-pressed steel, the fracture is always crystalline; the steel shell before them was the only projectile of its kind made for a gun supplied to the Brazilian Government. In reply to a further question, he stated that it had perforated 18 inches of wrought-iron, and it had not been fired against a steel or steel-faced target.

THE CHAIRMAN remarked on the general nature of the tests imposed on mild steel, and he requested the Lecturer to state the sources of his information about the recent production of steel projectiles, as he considered it of much importance to know the very latest advances made in this matter, which he understood to be still in progress, and not as yet brought to a satisfactory conclusion.

CAPTAIN MACKINLAY replied that though he agreed with Mr. Whinfield in considering the fracture of mild steel crystalline, that in some cases considerable appearance of fibre could be shown in the milder qualities fractured by bending, and a broken spoon test piece from the Royal Gun Factories was produced in support of this statement: a piece of Cammell's plate, which had been bent over double, also presented considerable indications of fibre at the fracture. With regard to steel projectiles, he believed Captain Orde Browne had done good service in calling attention to the necessity for their improvement; the Major-General had also alluded to the same subject, and the Lecturer stated with regard to his

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information concerning them, and the most recent experiments for their production generally for the service, that though he had had access to a few confidential papers, he hardly supposed that everything now being done in this direction was known to him: certain experiments with steel shells made in the Royal Gun Factories for the 43-ton gun were contemplated. Manufacturers seemed to find a difficulty in providing only a few shells, and as it took considerable trouble and expense to make the patterns desired, it was not worth their while unless a large number were ordered. One of them had said, "the Government expect us to make half-a-dozen new pattern shells, which we produce after great trouble and labour, and then if they succeed they may probably be copied in the Royal Arsenal"; on the other hand, as the Chairman had pointed out, the authorities naturally hesitate to order a large number of experimental shells until they feel sure that they fulfil the conditions required. The tests imposed by the Ordnance Committee on large masses of steel appear to have been remarkably stringent, and although they have been somewhat relaxed, they do not appear to give complete satisfaction to the steel trade. The manufacture in the R. G. F. has been begun and carried on with great perseverance and success by the present Superintendent—probably none except those who have actually undertaken the starting of steel works have any idea of the practical difficulties to be overcome: there is not, however, the necessary plant for very large ingots in the Royal Arsenal, and the production of steel is limited in amount by the small number of the furnaces. The manufacturers still supply a considerable proportion for the public service, and thus large and sudden demands can readily be met: but the Arsenal causes competition, and the officers who are themselves engaged in manufacture become more and more expert in judging of the merits of steel supplied from the great works of the country.

After some further remarks, the Chairman proposed a vote of thanks to the Lecturer, which was carried unanimously; after which the specimens of manufactured steel were further examined and discussed.

A considerable collection of interesting samples of manufactured steel were kindly sent for exhibition at the Lecture by the Superintendents of the Departments, Royal Arsenal, and Royal Small Arms Factory, Enfield; and also by various manufacturers and others, as under:—

The Royal Gun Factories (the only Government manufacture of steel) make steel in Price's (open-hearth) retort furnace, and sent some spoon tests from melted steel, a small gun hoop, a complete set of tests from the breech and muzzle end of an A tube before and after tempering, a fine specimen of good steel, and another of "burnt" steel, purposely overheated from the same bar to show the difference of fracture.

The Royal Laboratory sent an air receiver for a Whitehead torpedo of Whitworth steel, and a plate for torpedo boat protection, and tubular steel for rockets, shells, &c.

The Royal Carriage Department sent part of a tubular steel axletree, as well as a piece of steel casting for a Vavasseur carriage, shewing the fracture.

Sir J. Whitworth & Co. lent a long 9-inch shell of forged steel, and a set of test pieces.

Sir J. Brown & Co. and Messrs. Cammell & Co. each sent specimens of armour plate; the former sent a photograph of armour manufacture, and the latter a fine piece of gun steel, showing the fracture.

The Landore-Siemens Steel Company exhibited mild steel bars tied into knots and sections of angles and tee steel.

Messrs. Hadfield & Co. sent some excellent castings showing marks of having been well hammered but not broken: also a cast steel shell.

Messrs. Bolckow, Vaughan & Co. pieces of two steel rails from Cleveland ore; and Mr. Gilchrist sent other specimens of steel produced by the de-phosphorizing process from various works.

The Steel Company of Scotland provided samples of various plate and angle-steel used in ship-building, also specimens of ores, spiegel eisen, &c.

Mr. Delmard showed shells made in various ways from steel tubes, also small projectiles which had been stamped out from flat discs of steel, and some steel cartridge cases for sporting guns which could be re-loaded repeatedly.

Mr. Welsh, Royal Gun Factory, sent beautiful specimens of iron and steel, which had been melted in small crucibles, showing fracture.

The Royal School of Mines lent some diagrams, &c.

A large proportion of the above were kindly given, and they have been deposited in the Department of Artillery Studies.

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NOTE

ON THE

SUPPLY OF AMMUNITION TO GUNS IN A FORT,

AND SUGGESTION FOR

SIMPLIFICATION OF DRILL.

BY

CAPTAIN E. NASH, R.A.

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1. In fighting a fort armed with heavy guns it would be all important that there should be no hitch in the ready supply of ammunition, in order that the full power of the armament should be displayed.

2. Having this in view it becomes a question whether something more might not be done towards preparing for an emergency, and training men by practically showing them the actual circumstances which would befall in a time of action.

According to the present drill with these guns, the men who are supposed to be employed in the expense cartridge and shell stores remain idle, whilst the remainder of the detachment are working the gun. It is therefore suggested that:—

(i.) The gun detachment should consist only of the number of men actually required to work the gun; and

(ii.) That men required for employment in magazines and stores should form separate and distinct detachments, formed up in rear of the gun detachments, and told off for their different posts. These may be called "store detachments."

3. Under this system the present gun detachments would be reduced by three or four men; for the numbers now told off to issue ammunition from the stores do not in any way assist in the working of the gun itself. The gun detachment for the 9-inch gun would consist of eight men; for the 10-inch, ten men; and for the 12·5-inch, eleven men. They would be formed up and told off as before. Their duties would alter slightly, and instead of the present system, whereby a man's duties run through each drill according to his number, it is suggested that the lowest numbers should always take post next the

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gun, the highest go to the door of the expense shell store or head of the shell lift, and the next lower to the outside of the expense cartridge store or head of cartridge lift. The men would then perform duties according to their positions when under cover, and not, as heretofore, merely according to their numbers. This would appear to be the more intelligible method.

4. There should be in each fort a plan, on a large scale, say 25 feet to an inch, showing plainly every magazine and store, and on each of these should be recorded on the plan the number of men who could be conveniently employed therein. Suppose, now, a fort, or part of it, is to be manned for action. By reference to this plan, it will be at once seen how many men are required for the "store detachments." This number of men is formed up in rear of the gun detachments, told off for each magazine and store (irrespective of the guns), and marched off accordingly. It is not necessary they should know what particular guns they will supply with ammunition. Non-commissioned officers will also be told off (as circumstances will allow), and they will superintend the issue from the stores.

5. This being merely a suggestion, it would not be fitting to go into the question of duties, but the general plan of these should be, as regards the gun detachments, that the two highest numbers should supply the gun with shell, the next or two next lower numbers bring up the cartridge, and the remainder work the gun. Their actual duties will be according to their positions when "under cover."

As regards drill of the "store detachments," this will simply consist in telling off, marching to their respective stores and preparing to issue ammunition, attending to lamps, &c.

6. The plan above referred to must, of course, be kept handy in the fort, and it should show on each store (besides what has already been mentioned) the detail of ammunition contained therein—in pencil, because this continually changes,—also the number and description of the guns it supplies, and, if possible, the passage of the shell or cartridge to each gun or lift, in dotted lines—blue for shell, red for cartridge.

It should be borne in mind that there must be a constant supply of ammunition from the magazines and main shell stores to the expense stores, as well as from these latter to the guns.

7. Without making any alteration in the present method of drill and telling off of detachments, the above system may be carried out, in manning a fort, as follows:—Tell off the full gun detachments as usual. "Fall out" the numbers from each detachment who would be employed in the shell and cartridge stores, and march the remainder on the guns. Form up the numbers who have been thus "fallen out" and tell them off into "store detachments," as required. It will be found that there is a surplus of men. These will be useful for forming another gun detachment.

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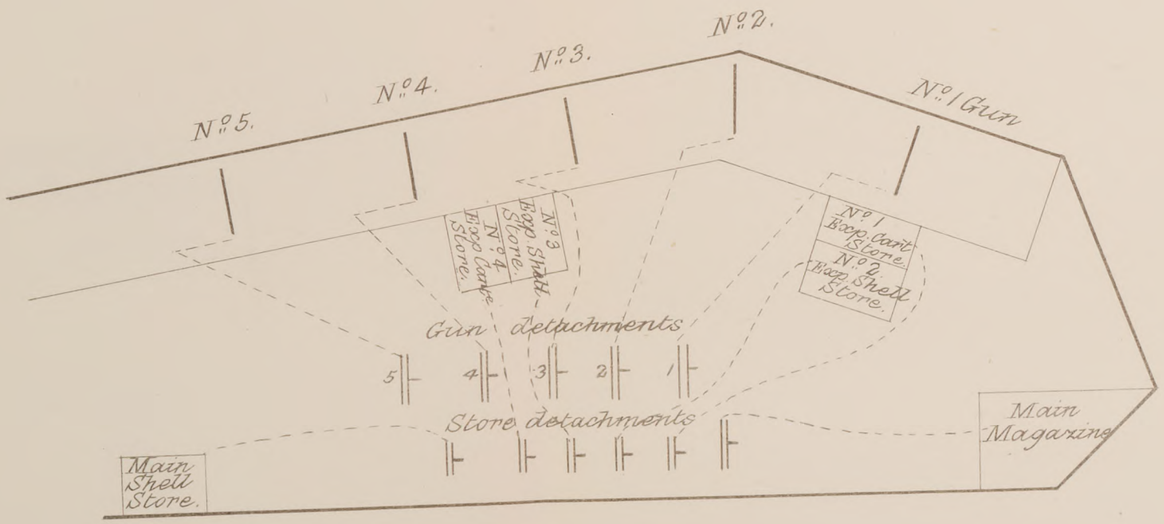
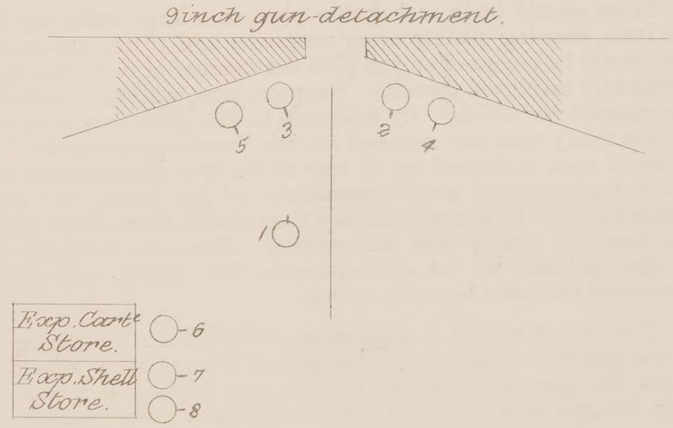
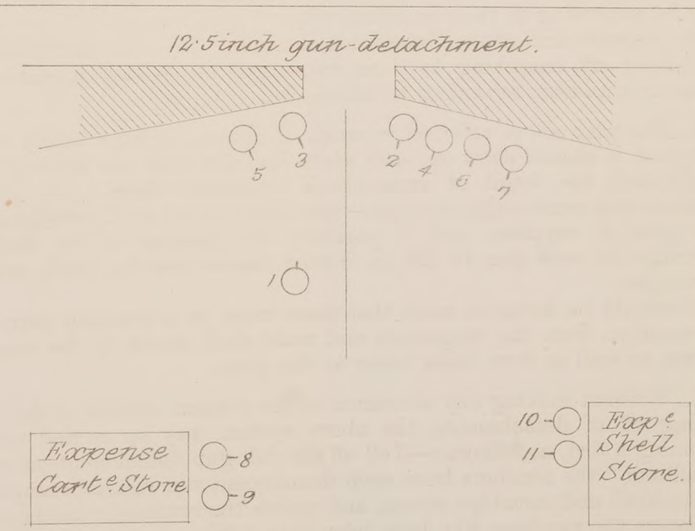

N°5.
N°4.
N°3.
N°2.
N°1 Gun
N°3 Exp. Shell Store.
N°4 Exp. Cartr. Store.
N°1 Exp. Cartr. Store.
N°2 Exp. Shell Store.
Gun detachments
5 4 3 2 1
Store detachments
Main Magazine
Main Shell Store.


9 inch gun-detachment.
5 3 2 4
1
Exp. Cartr Store. 6
Exp. Shell Store. 7
8


12·5 inch gun-detachment.
5 3 2 4 6 7
1
Expense Cartr.e Store. 8
9
10
11
Exp.e Shell Store.

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A SHORT REPORT OF THE LANDING OF EIGHT 12·5-INCH GUNS AT PRINCES DOCK, BOMBAY.

BY

LIEUT.-COLONEL S. PENNY, R.A.

FOUR of the eight guns were landed on the 1st February, 1883, two on the 9th, and two on the 10th of the same month.

The appliances for landing the guns were:—

Artillery Stores:—The *Ibis* (100-ton hydraulic) crane.
Two special 1½-inch cable chain slings.

A special 1½-inch cable chain sling was constructed as follows: from a large link big enough to pass over the shackle at the lower end of the crane's ram, were two lengths of cable chain; the longer length was 33 feet, the shorter 21 feet (Fig. 1), and to form a sling the running ends of the two lengths were brought together and fastened to each other with a shackle (Fig. 2). The two special slings were identical in construction, and the weight of each was 10⅛ cwt.

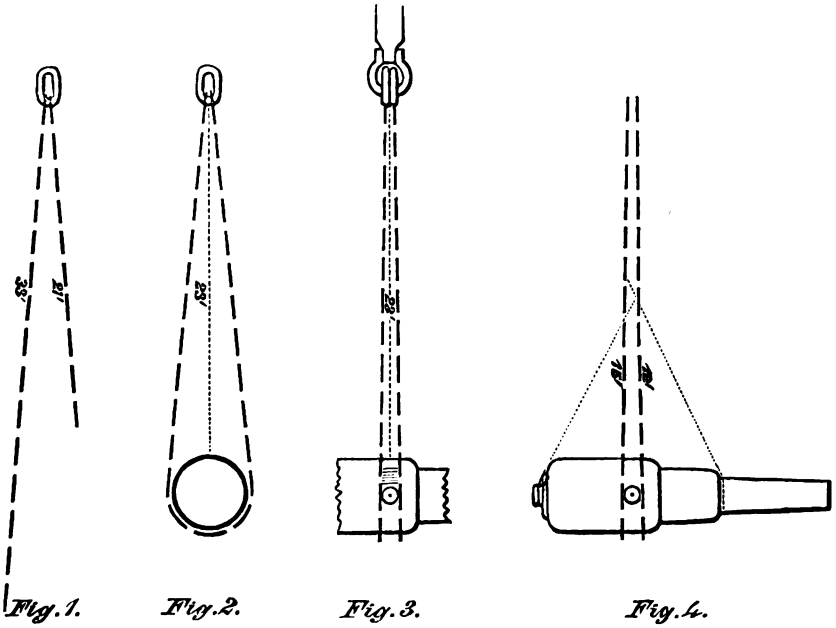

Fig. 1. *Fig. 2.* *Fig. 3.* *Fig. 4.*

The slings separately were made fast to the crane in the following manner: the crane shackle was removed and the large link at the

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upper end of each sling was placed on it, and then it was again attached as before to the lower end of the crane's ram.

The greatest diameter of the lower part of the shackle was 7 inches, and the diameter of the bolt which fastened the shackle to the ram was 4 inches.

The gun was slung as follows: one sling was placed immediately in front of the trunnions, the other immediately in rear of them, and the two slings on both sides of the gun were frapped and laced together with a piece 1½-inch wire rope above the trunnions (Fig. 3).

When the gun was slung there was 23 feet between it and the crane shackle; the reason of this was that the crane shackle was 7 feet above the level of the quay when the ram was lowered to its fullest extent; and it was calculated that the guns in the steamer's hold would be 16 feet below the level of the quay.

The muzzle sling had a $\frac{9}{16}$-inch rigging chain, 27 feet in length, fastened to it by a shackle at the height of 12 feet above the gun, this was passed round the neck of the cascable and made fast; another chain, similar in nature, size, and length, at the height of 15 feet above the gun, fastened to the breech sling, was passed round the gun at the junction of the B tube and B coil, and was made fast (Fig. 4).

These light chains were used as steadying chains, for the purpose of checking any tendency of the gun to dip at either breech or muzzle.

The crane now raised the gun high enough to clear the bulwarks, then it took the gun from off the steamer and placed it over the land. The first two guns of each four were lowered on to special railway gun-trucks, the remainder were lowered on to skidding and left at the dock until the trucks were sent back for their removal.

The following is a record of time taken in lifting and lowering the guns:—

No.	Began to sling.	On truck, or skids, or slings clear.	Total time.
			h. m.
137	10.15 a.m.	11.26 a.m.	1 11
136	12.20 p.m.	1.26 p.m.	1 6
134	2.0 "	2.26 "	0 26
133	2.45 "	3.27 "	0 42
139	10.15 a.m.	12.7 "	1 52
141	12.27 p.m.	1.10 "	0 43
140	10.43 a.m.	11.25 a.m.	0 42
138	11.35 "	12.17 p.m.	0 42

After landing No. 141 gun, when the slings were examined it was found that one link was bent, and on a more careful examination another link, near the bent link, was found to be unsound, owing to flaws in the metal at the junction of the stud and the link. New slings were supplied one-eighth of an inch larger, and were at Princes Dock the following morning at 9.45.

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BATTLE FIELDS

IN THE

LE MANS CAMPAIGN.

BY

CAPTAIN R. F. JOHNSON, R.A.

No. 2.

AZAY—MAZANGÉ

6th January, 1871.

THERE were two actions almost independent of one another, just west of Vendôme, on the 6th of January, but as the two German Divisions engaged advanced together, and the ground passed over can be seen at a glance, they will at first be treated as one.

To gain a general idea of the country, ascend to the ruins of the old Castle of Vendôme and take a position near one of the western towers. Below you at the bottom of a precipitous bank lies the sleepy country town, traversed by two branches of the River Loir, here about 30 feet broad. The houses extend to the north as far as the line of rail, which runs mostly on a slight embankment, forming the cord of the arc described by the river. Beyond the railway is a flat cultivated plain about three quarters of a mile broad, bounded by a straight bank about 60 feet high, covered with vines, which also forms the cord of the river curve from Courtiras to St. Ouen. Above Courtiras on the left the St. Calais road can be seen ascending a valley, cutting through the low straight bank to the higher ground beyond. A little to the right of this lies a large forest spreading to the right and left as it recedes. Straight in front of you on the top of the bank is the white Bel Air Chateau. One German Division, having crossed at Vendôme and just above the railway bridge on the right (which did not then exist), moved along the St. Calais road, sending a detachment by Bel Air Chateau; the other, having crossed at Vendôme, followed the bank of the Loir to Courtiras, and then continued on to the westward along the foot of the steep slopes which bound a large flat plain, hidden from your position by some high ground immediately on your left.

The Germans on the morning of the 6th of January, had 2 Battalions placed as outposts on the top of the bank north of the plain beyond the railway and another marching westward on the high ground.

To reach Courtiras turn to the left (W.) after crossing the river and

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to the right (N.W.) at the second turning after passing under the railway. The village, which may almost be regarded as a suburb of Vendôme, lies at the mouth of a small narrow valley running down from the west side of the Vendôme Forest. The main road ascends along the western bank of this small depression, and soon attains a large plateau perfectly open, and covered with vineyards in all directions. After reaching the crest, the road falls slightly for about 200 yards, and then rises gradually across the plateau for a mile and a half; on the left the southern crest is distant at first about 2000 yards, but recedes by degrees; on the right lies the forest rapidly receding from the line of road.

At the highest point of the road, a valley can be seen in front, mostly hidden by reason of the steepness of its hither bank, but bounded on the other side by fine open slopes, backed by an open cultivated country rising gently to the west; it is the valley of the Azay (or Azé, or Danzé), brook.

Turn toward Vendôme. You will see that the open plateau you have just passed over has two watersheds, one of which commences where the main road reaches the crest above Courtiras, and running almost due east, passes about 2000 yards on your right; the other begins 200 yards on your right, and runs N.E. through your position. They are separated by a small valley which commences just to your right front, and curves round to your right rear to that of the Azay. On your right, about 100 yards from the road is the farm of Le Plessis, lying in a group of trees on the west side of the small valley, here nothing but a depression, protected to the east by a hedge 50 yards from the house, and on the other slope of the depression by a copse. Just to your left rear is a line of cottages called La Charbonnerie and half a mile on your left a small farm, La Mérillière, on the watershed line. Close by the forest, well to the front, is a small solitary house La Briochetterie. These places were all *points d'appui* in the action about to be described. Villiers, a large village (1300 inhabitants) is nearly 2 miles south of you at the bottom of the slopes bounding the plateau, and quite out of sight.

On the cold clear morning of the 6th of January, with the ground covered with snow, numerous French troops advance from the westward over this plateau towards Vendôme. Colonel Thierry states their number on this road to be 2000, but they appear much more from the front they occupy. They are in good spirits and intend to-day to clear this side of the Loir of the hated Germans.

At 9.30 some firing is heard to the south-west, probably some outposts skirmishing in the valley, near Villiers. Soon there is firing all along the far side of the plateau; to the south it is a Prussian Battalion stopped in its march westward near Villiers; in front the two German Battalions on outpost duty, are stopping the French advance and preparing for a forward movement.

The French are surprised, for they intended to take the offensive part; but as the enemy appear determined, dispositions are taken for defence. The Azay valley forms naturally a strong line, so 200 men are placed in the village of that name, and 300 in La Galette, some cottages at the

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point where the main road crosses the brook. Three guns (or more?) are placed on the western slope to sweep the road in its descent, and the remainder of the force disposed to resist the hostile advance in the farms on the plateau.

The German attack is not pushed on, so a Battalion is sent into the Vendôme forest in order to issue on their right flank, when they move forward from the crest along the road.

The skirmishing grows gradually warmer. The French become more confident, and at 11 a.m., the Battalion attacks from the wood. The Germans, however, hold their own, and have now a support of 1 Battalion, 1 Squadron, and 6 Horse Artillery guns in Courtiras, halted on their way westward along the valley of the Loir. So pass two more hours. But at 1 o'clock there are evident signs that the real combat is about to commence. An advanced guard from the north of Vendôme has reached Courtiras, it consists of 2½ Battalions, 2 Squadrons and 12 guns. Three more Battalions are marching to support the one checked above Villiers. And orders have been sent back for half a Battalion to move by Bel Air Chateau, and through the forest on to the French left; and 1 Battalion is sent to join it from Courtiras. The two Battalions on outpost are relieved, being required to join their own Corps to the S.W. on the other side of the Loir Valley.

At 1.30, 1½ Battalions are advancing, deployed across the main road, and 3 Battalions on the plateau above Villiers. The ground is open, the Chassepôt far reaching, and many a helmet rolls in the snow. But the German advance never falters, and in three quarters of an hour is level with your position; the buildings of la Briochetterie, La Mérillière, La Charbonnerie, and Le Plessis having been captured, and the edge of the Azay valley reached on the left of the line.

From this time the actions become separated. That at Azay will be followed first.

Cross the valley and ascend the western side to an open spot above the road where it turns again to the north-west, after a detour to the north for the purpose of taking the slope at a gentler gradient.

Before you is the narrow valley of the Azay in which, to your left (N.E.), lies the closely built village (980 inhabitants) half a mile away. In front of you is La Galette, the collection of cottages by the bridge; and between them and the village, the large buildings of La Fosse, close under the eastern bank. The far side of the valley is very steep and woody, except for a short distance north of the road, where the ground is cultivated and slopes uniformly from the Le Plessis-Le Mérillière watershed line, which is three quarters of a mile away from the brook. North of this clear space lies the farm of Le Boile at the top of the bank, with a small water course (about 30 feet deep and 50 yards broad, its sides covered with brushwood) running just in rear of it, at the end of which, where it meets the Vendôme forest, there can be seen the roof of another farm, Le Gorgeat. Between this water-course and the village of Azay the ground is divided into small fields by large hedges, which greatly favour the defence.

To the right (S.) the Azay valley curves slightly to the west and disappears from view. At the bend under the eastern bank is the large

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Chateau Courtosé; and to the south of this, on the top of the bank beyond a side-valley half hidden by the trees, can be seen the farm of Le Briard.

The bottom of the valley is meadow land, full, south of the main road, of poplar trees; and about 300 yards broad. The eastern side, on which you are, has open slopes very suitable for defence, but is cut by a deep side-valley full of wood, a short distance on your right opposite to La Galette.

In rear, the country is open except on the immediate left, where the farms of La Margotterie and Belatour are surrounded by small enclosures and orchards separated by tall hedges. A road from Azay to the main highway runs between these farms, up a slight depression.

At 2.15, the German fighting line of 1½ Battalions was on the sky line in front of you, from the main road to the Vendôme Forest. The French held the farms of Le Boile and Le Gorgeat, with the line of the the watercourse between them, and were showing a resolute front.

Six guns open on Le Boile from the high ground, and another Battalion enters the line, making its strength up to 2½ Battalions. In about half-an-hour this advance is resumed, and Le Boile and Le Gorgeat carried. The French retire to Azay, and the Germans push their right forward through the strip of forest stretching down towards that place. At the same time Le Briard, away to your right, is occupied by one of the Battalions which are fighting to the south.

At 3 p.m., 12 guns are firing on the French across the valley, from a position near Le Boile farm, but the French guns do not make much answer as they are short of ammunition, and are reserving what they have for the close Infantry combat.

In half-an-hour more, 30 German guns are in action alongside one another; 1½ Battalions have joined the right of the attack from the woods, having come up from Courtiras and Bel Air Chateau; 5¼ Battalions are massed in rear as a reserve, and 2 Battalions, which properly belong to the more southerly fight, are moving up along the main road.

The front line thus brought up to 4 Battalions, now moves against the French in the valley and on its western bank; ½ Battalion attacks La Galette, ¾ La Fosse, and 2¾ the village of Azay. The front of the French line is only 2000 yards, and the German Division moving by the main St. Calais road has 9¼ Battalions (say 7,500 men) and 18 guns on the spot. Everything appears to be going well with the attack, so the 2 Battalions and 12 guns belonging to the Division, which is moving westward more to the south, leave to rejoin it, and enter into the action which can be heard on your right.

The fighting is hot, but the Germans gain the buildings in the valley except those at La Galette where the defence is very gallant. The French still hold the western slopes, and when the assailants try to climb the heights they are met with a vigorous counter-attack supported by case shot from the Artillery, issuing from the enclosures around La Margotterie and Belatour homesteads. The French retreat is secured, except for the force at La Galette which is surrounded and compelled to surrender.

At 5 p.m. darkness and fatigue bring the fighting to an end.

All this time firing has been heard to the south, pausing for a considerable time in the valley, and then moving westward.

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To see the ground of this, called the Mazangé action, descend to La Galette, and turn along the road to the right (S.) The eastern slopes of the valley are extremely steep, covered with wood up to the crest, and almost, if not quite, impassable except by a few paths; the bottom is meadow land divided by hedges, and with many poplar trees; the brook is about 10 feet broad; the western slopes, along the bottom of which the road runs, are everywhere open, not very steep, and are commanded by the opposite bank at a range of 1000 yards at most. The hamlets of Vauraçon and Vauchalupeau are passed, the former halfway up the slope, opposite the mouth of the side-valley between Courtosé Chateau and Le Briard farm, the latter in a small ravine cutting the western slopes; La Ripopière is a farm building belonging to the latter hamlet lying by the roadside. The Liers mill is on the left of the road, and consists of 3 small buildings very close together. The road meets another running N.W. and S.E. at the end of the valley. Here all the view to the south is cut off by poplar trees which are thick even in winter. S.E. the brook is crossed by a stone bridge, and just at the end of the steep eastern bank of the valley lies part of the village called Le Gué du Loir, built right against the bank. N.W. there is a brook with a valley very similar to that of the Azay, but more woody and at first narrower. The road to the right runs under the north bank, which is precipitous, and leads to Mazangé (1100 inhabitants), a large village about 1 mile up the stream at a spot where the valley opens out.

Ascend to high ground on the right of the road at the junction of the two valleys. Here it will be seen that the right or southern bank of the Mazangé valley stretches straight across the mouth of the Azay, and continues on to the river Loir, which makes a sharp bend to the south, just by the village of Le Gué de Loir.

The top of this bank is open, and at its end, but hidden from you, is the village of Clouseaux. In front of you is the valley of the Azay, just described; in rear, an open country sloping gently upward to the west for a long distance. Le Briard farm can be seen to the left on the opposite heights, the Liers mill in the bottom, and the top houses of Vauchalupeau on your left. From the top of the steep bank opposite, open ground slopes gently upward for a little over 2000 yards where the highest point of the plateau is reached above Villiers.

At about 2.15 p.m., the Germans had reached the top of the bank opposite with 3 Battalions; the French had evacuated the plateau, but held Gué du Loir, and all the west side of the Azay, and had also considerable forces at Clouseaux to prevent any advance along the Loir.

At 2.30, 12 German guns have opened at a range of over 3000 yards from La Haute Boissière, the highest point of the plateau; one of their Battalions is above Gué du Loir, one has made a dash into the valley and seized the Liers Mill and Vauchalupeau, and the third has established itself at Le Briard. Now ensues a pause, for the French have a large Battery above Clouseaux sweeping the bottom of the valley, which is also completely commanded by rifle fire from the western side. The German guns try to silence the French above Clouseaux, but cannot do so at the range they are at.

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Three more German Battalions come across the plateau, and while half of one of them descends and captures Gué du Loir, another moves into line on the left; for the French bugles are sounding the advance, and dense swarms of skirmishers are moving forward from Clouseaux; these however make no serious attack. The German guns now move up to a position south of Le Briard, reducing their range by 1000 yards, and at 3.30, are joined by 24 more, and then the whole 36 pound away and succeed in silencing the French Battery in half-an-hour. When the guns are silenced at 4 o'clock the attack of the Infantry west of the Azay brook is prepared, and about this time the 2 Battalions which have been away to the north, join the line at Le Briard.

At 4.30, the Germans again make a forward move. Two Battalions cross and pass through Vauraçon; turn west leaving Mazangé well on their left; and then again turn to the left, so as to descend the valley of the Mazangé on to the village; two Battalions move on the left of the latter two from Le Briard; about ¾ Battalion march from Vauchalupeau straight on Mazangé, and one Battalion crosses the brook at La Ripopière and establishes itself strongly on the western slopes. The movement is followed by the two Batteries coming from the action going on before Azay; they must have come down the ravine between Courtosé Chateau and Le Briard.

At 5 p.m., Mazangé is stormed on three sides at once, and the 12 German guns enter into action against the French south of that village; the fighting, however, soon ceases.

During the day a detachment of 1 Battalion, 1¾ Squadrons, and 1 Pioneer Company has occupied Danzé, a village 3 miles above Azay after a slight combat; and 6 Battalions and 12 guns have been kept at Courtiras as a reserve for the two actions.

The German IIIrd, or Brandenburg Corps, has gained the line of the Azay, 4½ miles from Vendôme, at a cost of 39 officers and 400 men.

To return to Vendôme, pass through Gué du Loir. It will be seen that the road thence to the west end of Villiers, about 1½ miles, is a defile between the river Loir and the sandstone cliffs which, bounding the plateau to the north, made the German left quite safe from any counter attack. Villiers is a long village (1300 inhabitants), at the bottom of the slopes which here replace the cliffs. Eastward the river makes a large detour to the south, and the slope on the north of the road decreases in height and steepness till the river is again reached 1½ mile further on. La Haute Boissère, the first position of the German guns in this part of the field, can be reached by taking the first lane leading to the plateau; from this spot the ranges to the French position appear much less than they are in reality, because the valley between is hidden by the crest of the plateau. A good view is also obtained towards Azay; and the connection between the two actions in the morning, and the manner in which they gradually became separated as the day wore on, is easily understood.

The distance of the excursion is about 18 or 19 miles. A carriage costs 10 francs.

(To be continued.)

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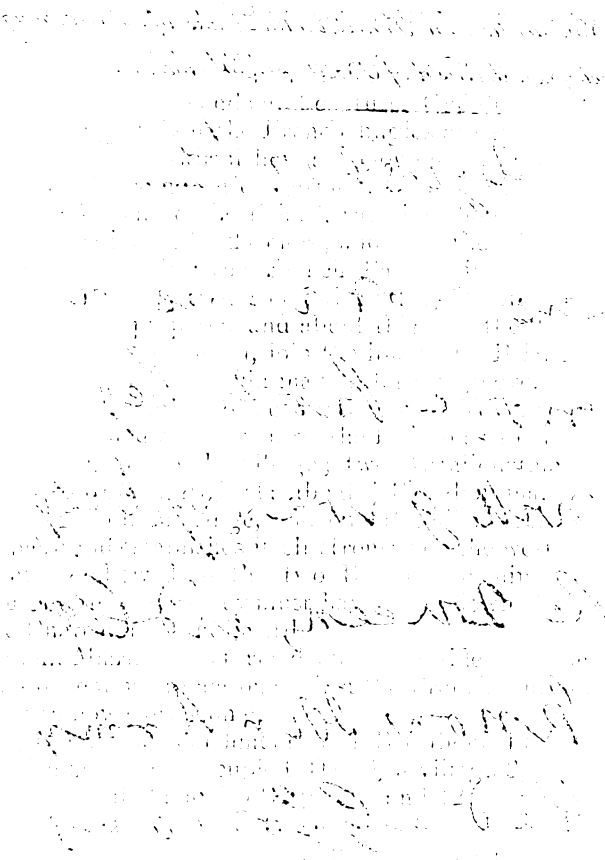
Fac-simile of the Note written in Pencil by the Duke of Marlborough to the Duchess on the Field of Battle at Blenheim.

August 13 1704

I have not time to say more, but to beg You will give my Duty to the Queen, and let her know Her Army has had a Glorious Victory Mons.r Tallard and two other Generals are in my Coach and I am following the rest the bearer my Aid de Camp Coll Parker will give Her



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and account of what
has pass'd, I shal doe
it in a day or two by
a nother more ~~alt~~
large

Marlborough

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